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XXIX. ON THE DISTRIBUTION OF THE NORTH AMERICAN HELVELLALES.

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The Helvellales with mostly a stalked ascoma open from the commencement of its development, form a somewhat natural group of fleshy fungi, with a few outlying members which are allied to several other discomycetous families and genera. Probably the most familiar form is the morel which is known in many parts of the country as "the spring mushroom," and in certain parts is even called "*the* mushroom" to the exclusion of other species of edible fungi. Several other species of the order are edible, but in this country little attention is paid to these delicacies and few of the possibilities of the group have been tested. The main object of the present paper is to show how little is known of the distribution of the group even among mycologists.

Three well marked families constitute the order. Of these the GEOGLOSSACEAE are mostly slender, stalked, club-shaped or capitate fungi varying in consistency from fleshy to gelatinous or waxy. Their asci open by means of a terminal pore. Most of the species are small, an inch or two high, and grow in various situations, more commonly on old decaying wood or leaves in rather moist places. In color they vary from black to light yellow or even white. Superficially they resemble the club-fungi (*Clavariaceae*) with which group, indeed, Fries united some of them as late even as 1838. [1] Some of the black forms also resemble some species of *Xylaria*, but the woody character of the latter genus will readily distinguish them.

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(1) Epicrisis Systematis Mycologici, 582-584. 1836-1838.

Twelve genera are recognized, nine of which are found in this country. They may be distinguished by the following table:

Ascoma clavate or subcapitate, continuous with the stipe.
  Spores one-celled, colorless.
    Light colored, usually yellowish or light brown; ascoma sharply separated from the stipe.................... **Mitrula.**
    Bright or dark colored; ascoma not clearly separated from the stipe.................................. **Microglossum.**
  Spores 2—many-celled by cross septae.
    Spores colorless.................................. **Leptoglossum.**
    Spores brown..................................... **Geoglossum.**
Ascoma flat, decurrent on both sides of the stipe; spores rod-shaped.................................. **Spathularia.**
Ascoma capitate or hollow-discoid usually with a free margin.
  Spores ellipsoid.
    Gelatinous-gristly .... **Leotia.**
    Waxy .... **Cudoniella.**
  Spores elongate-filiform.
    Fleshy; ascoma concave, hat-shaped, the margin free, incurved.. **Cudonia.**
    Waxy; ascoma discoid above, the margin adnate to the stipe.. **Vibrissea.**

Of the above genera we have one species in *Vibrissea*, two each in *Cudonia*, *Cudoniella*, and *Spathularia*, five in *Leotia* and six in *Mitrula*. The other genera are divided into well marked sections. *Geoglossum* is represented by ten species arranged in two sections:

§ *Eugeoglossum* with smooth stipes, containing *G. difforme, nigritum, ophioglossoides, peckianum,* and *viscosum.*

§ *Trichoglossum* with hairy or bristly stipes, containing *G. americanum, farlowi, hirsutum* and *velutipes. G. farinaceum* has not been collected since its first discovery by Schweinitz and its characters are, therefore, imperfectly known.

Leptoglossum also contains two sections:

§ *Euleptoglossum*, blackish, containing *L. microsporum* and *tremellosum.*

§ *Xanthoglossum*, yellowish or yellowish-brown, containing *L. luteum.*

Microglossum is likewise formed of two sections:

§ *Eumicroglossum*, containing the dark colored (olive-green) species, *M. viride*, and

§ *Geomitrula*, containing the bright colored (yellowish or reddish) species: *M. album, arenarium, elegans, lutescens, pistillare, rufum* and *vitellinum.* These were all united to *Mitrula* by Saccardo.

Of this family only *Leotia lubrica* is known to be edible. I have frequently seen this species growing in wet woods in Connecticut so abundant that several quarts could be gathered from an area of a few square rods.

The HELVELLACEAE are distinguished by the pileate character of the ascoma and especially by the method of dehiscence of the asci by opercula. This family contains the largest species of the order, some of them weighing a pound or more. Most of the larger species and some of the smaller ones are edible, and the morels and gyromitras form the most luscious of the esculent fungi. There are five genera all represented in America, distinguished as follows:—

Pileus fleshy, hollow throughout or at least in the upper portion.
- Pileus oval or conic, the upper surface consisting of deep pits formed by longitudinal and transverse ridges...... **Morchella.**
- Pileus irregular or lobed, the upper surface covered with gyrose wrinkles.................................... **Gyromitra.**

Pileus tough or fleshy, attached to the stipe at the middle.
- Pileus campanulate.................................... **Verpa.**
- Pileus flat or arched, almost discoid...................... **Cidaris.**
- Pileus lobed, irregular or saddle-shaped.................. **Helvella.**

Helvella is the largest genus, represented in this country by twelve species. These are divided into three somewhat natural groups according to the nature of the stipe.

(1) Stipe thick, sulcate or furrowed. *H. californica, crispa, grisea, lacunosa, palustris.*

(2) Stipe thick, smooth. *H. monachella.*

(3) Stipe slender, smooth (i. e. not sulcate). *H. atra, elastica, ephippum, gracilis, pezizoides, pusilla.*

Verpa contains two species and possibly a third representing two well marked sections:—

§ *Ptychoverpa* Boud. (*Morchellaria* Schroet.) with thick, simple or forked, longitudinal ridges on the pileus, is represented by *V. bohemica*, and

§ *Euverpa* with a smooth pileus, is represented by *V. conica*, and a second species with a dark colored pileus that may be identical with *V. atro-alba* Fries.

The first section was formerly regarded as a member of *Morchella*, but its true position was first pointed out by Boudier[2] in which he has been followed by both Schroeter[3] and Rehm[4].

(2) Bull. Soc. Mycologique, **7**: 141. 1892.
(3) **Engler-Prantl.** Die natürl. Pflanzenfam. **1**: 170. 1894.
(4) **Rabenhorst.** Krypt. Fl. Deutsch. Oesterr. und der Schweiz, Pilze, **3**: 1199. 1895.

Morchella has eight species likewise representing two sections:

§ *Eumorchella* Schroet. Pileus hollow throughout, the cavity continuous with that of the stipe. Contains *M. esculenta* and most of the other species some of which are possibly mere varieties of this species.

§ *Mitrophora* Lev., Pileus hollow above, the lower part free and surrounding the stem. Contains the two closely allied species *M. hybrida* and *rimosipes.*

Gyromitra contains seven species some of which are the largest members of the entire order and perhaps of the entire class of Ascomycetes.

Cidaris contains a single Schweinitzian species which is unknown except from its original description.

The third family, RHIZINACEAE, are stemless plants forming in some genera connections with the Pezizales. They resemble the *Helvellaceae* in the dehiscence of the asci by opercula. Four genera are known, one of which, *Sphaerosoma,* with spherical spores, is found only in Europe. The other genera are found in America and can be separated as follows:—

Ascoma firm, fleshy, flattish or arched.
 Smooth beneath .... **Psilopezia.**
 With root-like fibrils beneath.............................. **Rhizina.**
Ascoma fleshy, columnar, the interior with longitudinal chambers.................................. **Underwoodia.**

Psilopezia is represented by two species on the continent and an additional one in Cuba. *P. nummularis* is a thick flattish, dark colored species the size of a five cent piece or a little larger, looking like a flattened *Peziza.* It is not uncommon on wet mossy logs in the northern states in which I have collected.

Rhizina contains two American species, one of which is found only in Cuba.

Underwoodia is peculiar to this country and has so far been found in only one locality, Kirkville, Onondaga County, New York. It was first discovered in 1889, by Dr. Joseph T. Fischer, a former companion on fungus forays, and although it has been carefully looked for at its season every year since, it has been met with only twice (21 June, 1890, and 19 June, 1893). Three plants were found the first time, two the second (one of which was double), and the third only the fragment of one that was distorted in attempting to push up through the somewhat dry earth, but clearly showing the very peculiar interior structure which characterizes the genus. Like most of the members of this order it appears to have a brief period during

which it matures spores, the rest of the time remaining underground and invisible in its vegetative condition.

It is over twenty years since a list of the members of this order of plants known to grow in America has been published. Schweinitz [5] in 1834, gave a list of those known to him, including 24 species. No further general list was published until 1875 when Cooke [6] recorded 41 species. Of these one species (*Mitrula inflata* Fr.) has been shown by Peck [7] to belong to a distinct group, and a second species (*Psilopezia babbingtonii*) has been reduced leaving nominally 39 species belonging to ten genera. In the present list which simply records the species which have been reported, without attempting to determine the accuracy of the determinations, we give 73 nominal species arranged in 17 genera, an increase of over 82 per cent. for the last two decades of exploration. In recent years there have been several partial rearrangements of genera and in Europe a considerable critical work on the species. There is still considerable work of this kind necessary on the material already reported from America and as the following will show we have only begun to know anything of distribution. Besides the generic arrangement of Saccardo [8] after which the species of the Sylloge were arranged, we have two by Schroeter, one [9] of which covers the 34 species of Silesia, and the other [10] includes descriptions of all the genera. Following these we have the wholly similar arrangement of Rehm [11] covering the 73 species of Central Europe (Germany, Austria and Switzerland). Phillips' [12] earlier revision of the species of the British Isles included 44 species. Of the American species, 31 (about 40 per cent.) are also found in Europe, the remaining species appearing to be endemic. In distribution they extend all the way from Cuba to Greenland and from Southern California to Behring's Strait. The following distribution by states represents more properly the poverty of our collections from various parts of the country than the actual abundance in the various sections. It will also point out to

(5) Synopsis Fungorum in America Boreali media degentium. Trans. Amer. Philos. Soc. **4**:169, 170, 178, 181. 1834.

(6) Synopsis of the Discomycetous Fungi of the United States. Bull. Buffalo Soc. Nat. Sci. **2**: 285-300. 1875.

(7) Fungi in wrong genera. Bull. Torr. Bot. Club, **9**: 1-4. 1882.

(8) Conspectus genera Discomycetum hucusque cognitorum. Bot. Centralblatt. **18**: 213-220, 247-256. 1884.

(9) **Schroeter.** Kryptogamen Fl. von Schlesien, **3**: 16-31. 1893.

(10) Helvellineae, in Engler-Prantl. Die naturl. Pflanzenfam. **1**: 162-172. 1894.

(11) **Rehm.** Pilze. **3**: 1134-1208. in Rabenhorst. Krypt. Flora. 1895.

(12) **Phillips.** A Manual of the British Discomycetes. 1887.

future collectors the regions where field work is sadly needed in contrast with those states that are fairly well explored. In this way New York stands at the head of the list with thirty-four species because of the untiring work of her veteran botanist, Charles H. Peck. Massachusetts and North Carolina follow, the former with 18 species [13] and the latter with 16. In the first named state there have been numerous collectors; the latter was the early collecting ground of Schweinitz and later that of Curtis. California stands fourth with 13 species representing the earlier work of Harkness and the later of McClatchie. Then follow Rhode Island with 11 and Pennsylvania with 10, the latter representing the later work of Schweinitz. South Carolina and New Jersey each have 9, the work of Ravenel in the South and Ellis in the North. Wisconsin has 8, Nebraska has 7. Then come Indiana and Greenland with 5 each. Ohio and Connecticut and New Hampshire, with 4, Minnesota, Illinois, Alabama and Cuba with 3, Maine, Kansas, Iowa, Louisiana and Florida with 2, and Vermont, Maryland, Virginia, Kentucky, Mississippi, Michigan, Ontario. British Columbia and Alaska, each with a single species. It will thus be seen that of the 49 states and territories of the United States, not a single species of the order Helvellales, one of the conspicuous groups of fungi, have been collected in 21 states, and only eleven states have furnished as many as five species. In the face of facts like these, there are those who persistently maintain that the work of the systematic botanist in America is nearly exhausted! Over vast portions of our domain the collector of even our most conspicuous fungi has never yet roamed, and the example of New York shows clearly that in well known regions additional species and even genera are continually coming to light.[14] The species are mostly transitory, some of them are apparently local in their range, many are erratic in their appearance—occurring one year and missing three or four, turning up in

(13) There are some four species reported simply from "New England" without closer reference. It is therefore fair to state that from all New England 27 species have been reported.

(14) As an illustration of this we give the dates at which the species of New York were first collected as announced in Peck's annual reports.

1868 (22nd Report.) 4 species	1876 (30th Report.) 4 species.
1869 (23rd ") 3 "	1878 (32nd ") 3 "
1870 (24th ") 6 "	1879 (33rd ") 1 "
1871 (25th ") 5 "	1883 (37th ") 1 "
1873 (27th ") 3 "	1885 (39th ") 2 "
1874 (28th ") 1 "	1889 (43rd ") 1 "
1875 (29th ") 1 "	

unexpected quarters and at unexpected seasons,—so that the traveling or random collector is only likely to see the more common ones. It will be years before even our higher fungous flora will be even fairly well known.

In the list that follows the distribution given represents (1) The original or type localities from which the plants were described. (2) The published local lists of fungi. (3) Species mentioned in miscellaneous incidental notes occurring in botanical literature, and (4) Specimens occurring in the writer's herbarium, which hitherto have not been reported from their respective localities. It is more than likely that some minor references have been missed and the writer would be greatly obliged not only for corrections of this character but more especially for the communication of species from all quarters, especially from those regions where few or no species have been heretofore reported.

The types of the species should be distributed somewhat as follows. The writer expects to examine all of these which are available before a monograph of the species is attempted.

European types mostly unavailable as described by early authors, 36.

At Kew, 15 (Berkeley and "B. & C." types 8, Cooke types 7)

At Albany, N. Y. (Peck types) 9.

At Philadelphia, Pa. (Schweinitz types) 7.

At Newfield, N. J. (Ellis types) 1.

At Preston, Ohio, (Morgan types) 1.

At Auburn, Ala. (Underwood types) 2.

Besides these there are two of Bosc's species (1811) of whose types I have no knowledge.

HELVELLACEÆ.

I. HELVELLA L. Sp. Pl. 1180. 1753.. [*Elvela* the original orthography].

1. **Helvella atra** König. Fl. Island, 20. 1770.
   H. nigricans Pers. Obs. Myc. **1**: 72. 1796.

   South Carolina (*Ravenel*). [Europe].

2. **Helvella californica** Phill. Trans. Linn. Soc. **1**: 423, *pl. 48.* 1880.

   California (*Harkness, McClatchie,*) British Columbia (*Macoun*)

3. **Helvella crispa** (Scop.) Fr. Syst. Myc. **2**: 14. 1822.
   Phallus crispus Scop. Fl. Carn. **2**: 475. 1772.

New England (*Sprague*), Massachusetts (*Frost*), Rhode Island (*Bennett*), New York (*Peck*, *Underwood*), Maryland (*Banning*), North Carolina (*Curtis*), Illinois (*Brendel*), Wisconsin (*Bundy*) Nebraska (*Bot. Surv.*) California (*Harkness*, *McClatchie*). [Europe].

4. **Helvella elastica** BULL. Champ. Franc. 299. *pl. 242.* 1785.

New York (*Peck*) Massachusetts (*Frost*, *Underwood*), Rhode Island (*Bennett*), Nebraska (*Bot. Surv. Neb.*), California (*McClatchie*). [Europe].

5. **Helvella ephippium** LEV. Ann. des Sc. Nat. II. **16**:240, *pl. 15, f. 7.* 1841.

Rhode Island (*Bennett*), Massachusetts (*Frost*), Virginia (*Curtis*), North Carolina (*Curtis*). [Europe].

6. **Helvella gracilis** PECK. Reg. Rep. **24**: 94. 1872.
New York (*Peck*).

7. **Helvella grisea** CLEMENTS. Bot. Surv. Neb. **4**:8. 1896.
Nebraska (*Bot. Surv.*)

8. **Helvella lacunosa** AFZ. Act. Holm, 304. 1783.
Helvella sulcata AFZ. Vet. Akad. Handl. 305. 1783.

New Hampshire (*Farlow*), Massachusetts (*Frost*), Rhode Island (*Bennett*), New York (*Peck*), New Jersey (*Ellis*), Pennsylvania (*Schweinitz*), Wisconsin (*Bundy*), North Carolina (*Schweinitz*, *Curtis*), South Carolina (*Curtis*), Alabama (*Curtis*), Nebraska* (*Bot Surv.*), California (*Harkness*, *Blasdale*, *McClatchie*). [Europe].

8a. **Helvella lacunosa minor** ROSTR. Medd. om Grönl. **3**:605. 1891.

Greenland (*Rostrup*).

9. **Helvella monachella** (SCOP.) FR. Syst. Myc. **2**: 18. 1822.
Phallus monachella SCOP. Fl. Carn **2**: 476. 1772.

New England (*Sprague*), California (*Harkness*). [Europe].

10. **Helvella palustris** PECK. Reg. Rep. **33**: 31. *pl. 2. f. 16–18.* 1883.

New York (*Peck*).

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* The form here reported is described (*l. c.* 8) as *Helvella sulcata minor* CLEMENTS which is preoccupied under the present species. It may or may not be the same form as the next from Greenland.

·11. **Helvella pezizoides** AFZ, Vet. Ak. Handl. 308. *Pl. 10. f, 2.* 1783.

Nebraska (*Bot. Surv.*)

12. **Helvella pusilla** B. & C. Amer. Acad. Arts. and Sci. **4**:127. 1858.

"Behring's Strait."

EXCLUDED SPECIES.

Helvella acaulis PERS. Syn. Meth. fung. 614. 1801.—*Rhizina inflata.*
Helvella costata SCHW. Syn. fung. Car. 1822.—*Gyromitra costata.*
Helvella esculenta PERS. Champ. comm. 220, *pl. 4.* 1800—*Gyromitra esculenta.*
Helvella gigas KROMBH. Schwämme **3**:28, *pl. 20, f. 1–5.* 1834.—*Gyromitra gigas.*
Helvella grandis CUM. Act. Taur. *pl. 2.* 1805.—*H. monachella.*
Helvella infula SCHAEFF. Icon. fung. *pl. 159.* 1763.—*Gyromitra infula.*
Helvella macropus (PERS.) KARST. Myc. Fenn. **1**:37. 1871.—*Macropodia macropus.*
Helvella sphaerospora PECK. Reg. Rep. **27**:106. 1875.—*Gyromitra sphærospora.*
Helvella sulcata AFZEL. Vet. Akad. Handl. 305. 1783.—*H. lacunosa.*

II. GYROMITRA FR. Summa Veg. Scand. 346. 1849.

1. **Gyromitra brunnea** UNDERW. Proc. Ind. Acad. Sci. for **1893**:33. 1894.

Indiana (*Underwood*), Ohio (*Lloyd*), Kentucky (*Price*).

2. **Gyromitra caroliniana** (BOSC) FR. Ofvers. vet. Akad. **1871**:173. 1871.

Morchella caroliniana BOSC, Berl. Mag. Naturf. 86, *pl. 5, f. 6.* 1811.

North Carolina (*Curtis*), Massachusetts, New York (*fide Schweinitz*), Pennsylvania (*Schweinitz*).

3. **Gyromitra costata** (SCHW.) COOKE. Mycogr. 194. *pl. 91. f. 332.* 1879.

Helvella costata SCHW. Syn. fung. Car. 1822.

North Carolina (*Schweinitz, Curtis*).

4. **Gyromitra esculenta** (PERS.) FR. Summa Veg. Scand. 346. 1849.

Helvella esculenta PERS. Champ. comm. 220 *pl. 4.* 1800.

Maine (*Bolles*), New Hampshire (*Minn*), Massachusetts (*Sprague, Frost*), New York (*Torrey, Peck*), Ohio (*Lea*), Illinois (*Brendel*), California (*Harkness*). [Europe].

5. **Gyromitra gigas** (KROMBH.) COOKE. Mycogr. 191, *pl. 88, f. 327.* 1879.

Helvella gigas KROMBH. Schwämme, **3**: 28. *pl. 20. f.* 1–5. 1834.
*Gyromitra curtipes** FR. At. Svamp. *pl. 56.* 1869.

New York (*Peck*). [Europe].

6. **Gyromitra infula** (SCHAEFF.) QUEL. Enchir. fung. 272. 1886,

Helvella infula SCHAEFF. Icon. fung. *pl. 159.* 1763.

New York (*Peck*), North Carolina (*Schweinitz, Curtis*). [Europe].

7. **Gyromitra sphærospora** (PK.) SACC. Syll. fung. **8**: 16. 1889.

Helvella sphœrospora PK. Reg. Rep. **27**: 106. 1875.

New York (*Peck*).

III. VERPA SWZ. Vet. Akad. Handl. **1815**: 129. 1815.

1. **Verpa bohemica** (KROMBH.) SCHROET. Schles. Krypt. Fl. **3**: part 2. 25. 1893.

Morchella bohemica KROMBH. Monatschr. böhm. Nat. Mus. 1828; Schwämme, **3**: 3, *pl. 15, f. 1–13, pl. 17, f. 5–8.* 1834.
Morchella gigaspora COOKE. Trans. Bot. Soc. Edinb. **10**: 440. 1870.
Morchella bispora SOROKIN. Myc. Unters. 21. *pl. 6. f. 1–3.* 1872.
Morchella bispora var. *truncata* PK. Reg. Rep. **46**: 38. 1893.

New York (*Peck, Underwood*), Michigan (*Hicks*). [Europe].

2. **Verpa conica** (MILL.) SWZ. Vet. Akad. Handl. 136. 1815.

Phallus conicus MILL. Fl. Dan. *pl. 654. f. 2.* 1770.
Verpa digitaliformis PERS. Myc. Europ. 202. *pl. 7. f. 1–3.* 1822.

New York (*Peck, Fischer*), Wisconsin (*Bundy*), California (*Harkness*). [Europe].

EXCLUDED SPECIES.

Verpa caroliniana SCHW. Syn. fung. Bor. Am. 170. 1834.—*Cidaris caroliniana.*
Verpa digitaliformis PERS. Myc. Europ. 202. 1822.—*V. conica.*

IV. CIDARIS FR. Summa Veg. Scand. 347. 1849.

1. **Cidaris caroliniana** (SCHW.) FR. Summa Veg. Scand. 347. 1849.

Verpa caroliniana SCHW. Syn. fung. Am. Bor 170. 1834.

North Carolina (*Schweinitz*).

(*) Rehm, in Rabenh. Krypt Fl. Deutsch. **1**: part 3, 1193, unites this species with *G. gigas.* If Cooke's figures in Mycographia are to be relied on, we doubt the propriety of uniting the two species. It is *G. curtipes* that has been collected by Peck.

V. **MORCHELLA** Pers. Tent. Disp. Meth. Fung. 36. 1797. [Ex Dill. 1719].

1. **Morchella angusticeps** Pk. Bull. N. Y. Mus. **1**:19. *pl. 1. f. 19–21.* 1887.

New York (*Peck, Underwood*).

2. **Morchella conica** Pers. Champ. com. 257. 1818.

M. deliciosa Fr. Syst. Myc. **2**: 8. 1822.

Rhode Island (*Olney*), New York (*Peck, Underwood*), Pennsylvania (*Everhart*), Ohio (*Lea*), Indiana (*Underwood*), Kansas (*Cragin*), California (*Harkness, McClatchie*), Greenland (*Rostrup*). [Europe].

3. **Morchella crassipes** (Vent.) Pers. Syn. Meth. fung. 620. 1801.

Phallus crassipes Vent. Mem. Inst. Nat. **1**:*509. f. 2.* 1798.

Kansas (*Cragin*). [Europe].

4. **Morchella elata** Pers. Syn. Meth. Fung. 618. 1801.

? *Phallus elatus* L. Sp. Pl. 1178. 1753.

New England (*Sprague*). [Europe].

5 **Morchella esculenta** (L.) Pers. Syn. Meth. fung. 618. (1801).

Phallus esculentus L. Sp. Pl. 1178. 1753.

New England (*Sprague*), Massachusetts (*Frost, Farlow*), Rhode Island (*Bennett*), New York (*Peck*), New Jersey (*Ellis*), Pennsylvania (*Schweinitz*), Maryland (*Banning*), North Carolina (*Schweinitz, Curtis*), Ohio (*Lea*), Indiana (*Underwood*), Wisconsin (*Trelease, Bundy*), Illinois (*Brendel*), Iowa (*Bessey, McBride*), Nebraska (*Webber*), Kansas (*Cragin*), California (*Harkness*), Cuba (*Wright*), Mexico. [Europe].

6. **Morchella foraminulosa** Schw. Syn. fung. Am. Bor. 169. 1834.

North Carolina (*Schweinitz*). A doubtful species.

7. **Morchella hybrida** (Sow.) Pers. Syn. Meth. fung. 620. 1801.

Helvella hybrida Sow. Fungi. *pl. 238.* 1801.

Morchella semilibera D. C. Fl. Franc. **2**: 212. 1815.

Massachusetts (*Farlow*), New York (*Peck*), Indiana (*Underwood*), Ontario (*Dearness*). [Europe].

8. **Morchella rimosipes** DC. Fl. Franc. 2: 214. 1815.

New York (*Underwood*), Indiana (*Underwood*), Wisconsin (*Trelease*). [Europe].

EXCLUDED SPECIES.

Morchella bispora SOROK. Myc. Unters. 21. 1872.—*Verpa bohemica*.
Morchella bohemica KROMBH. Monatschr. böhm. Nat. Mus. 1828. —*Verpa bohemica*.
Morchella caroliniana BOSC, Berl. Mag. Naturf. 86. 1811.—*Gyromitra caroliniana*.
Morchella deliciosa FR. Syst. Myc. **2**: 8. 1822.—*M. conica*.
Morchella gigaspora COOKE. Trans. Bot. Soc. Edinb. **10**: 440. 1870. —*Verpa bohemica*.
Morchella semilibera DC. Fl. Franc. **2**: 212. 1815.—*M. hybrida*.

GEOGLOSSACEÆ.

I. GEOGLOSSUM PERS. Obs. Myc. 1: 11. 1795.

1. **Geoglossum americanum** (COOKE) SACC. Syll. Fung. **8**: 46. 1889.

G. hirsutum var. *americanum* COOKE. Mycogr. 3. *pl. 1. f. 1.* 1879.

New York (*Gerard*).

2. **Geoglossum difforme** FR. Obs. Myc. **1**: 159. 1824.

Massachusetts (*Frost*), Rhode Island (*Bennett*), New York (*Peck*), North Carolina (*Curtis*), South Carolina (*Curtis*). [Europe].

3. **Geoglossum farinaceum** SCHW. Syn. Fung. Car. 1822.

North Carolina (*Schweinitz*). A doubtful species.

4. **Geoglossum farlowi** COOKE, Grev. **11**: 107. 1883.

Massachusetts (*Sturgis*).

5. **Geoglossum hirsutum** PERS. Comm. Schäff Icon. Fung. Bav. 37. 1800.

Massachusetts (*Hitchcock, Frost*), Rhode Island (*Bennett*), New York (*Peck*), New Jersey (*Ellis*), North Carolina (*Schweinitz, Curtis*), South Carolina (*Curtis*), Lousiana (*Hale*), Cuba (*Wright*). [Europe].

6. **Geoglossum nigritum** (FR.) COOKE. Mycogr. 205, *pl. 96. f. 345.* 1879.

Clavaria nigrita FR. Epicr. 578. 1838.

New York (*Peck*), Nebraska (*Bot. Surv.*) [Europe].

7. **Geoglossum ophioglossoides** (L.) SACC. Syll. Fung. **8**: 43. 1889.

Clavaria ophioglossoides L. Sp. Pl. 1182. 1753.
Geoglossum glabrum PERS. Obs. Myc. **2**: 61. 1796.
Geoglossum simile PK. Reg. Rep. **25**: 97. 1873.

Massachusetts (*Frost*), Rhode Island (*Farlow*), New York (*Peck*), New Jersey (*Ellis*), North Carolina (*Schweinitz, Curtis*), Nebraska (*Bot Surv.*) [Europe].

8. **Geoglossum peckianum** COOKE. Grev. **3**:150. 1875.
New York (*Peck*), New England (*Murray*), Florida (*Ravenel*).

9. **Geoglossum velutipes** PK. Reg. Rep. **28**:65. 1876.
New York (*Peck*), Mississippi (*Tracy*).

10. **Geoglossum viscosum** PERS. Obs. Myc. 40. *pl. 5. f. 7.* 1796.
New York (*Peck*). [Europe].

EXCLUDED SPECIES.

Geoglossum album JOHNS. Bull. Acad. Nat. Sci. Minnesota. **1**: 1878.—*Microglossum album.*

Geoglossum glabrum PERS. Myc. Obs. **2**: 61. 1796.—*G. ophioglossoides.*

Geoglossum irregulare PK. Bull. N. Y. State Mus. **1**:28. 1887.—*Microglossum vitellinum irregulare.*

Geoglossum luteum PK. Reg. Rep. **24**: 94. 1872.—*Leptoglossum luteum.*

Geoglossum microsporum CKE. and PK. in Peck: Reg. Rep. **25**: 97. 1873.—*Leptoglossum microsporum.*

Geoglossum pistillare B. and COOKE. Mycogr. 206. *pl. 96. f. 348.* 1879.—*Microglossum pistillare.*

Geoglossum rufum SCHW. Syn. fung. Am. Bor. 181. 1834.—*Microglossum rufum.*

Geoglossum simile PK. Reg. Rep. **25**:97. 1873.—*G. ophioglossoides.*

Geoglossum tremellosum COOKE. Mycogr. 206. *pl. 96. f. 347.* 1879. —*Leptoglossum tremellosum.*

Geoglossum viride PERS. Comm. 40. 1797.—*Microglossum viride.*

II. MICROGLOSSUM GILLET, Discom. Franc. 25. 1879.

1. **Microglossum album** (JOHNS.)
Geoglossum album JOHNS. Bull. Acad. Nat. Sci. Minnesota. **1**: 1878.
Mitrula johnsonii SACC. Syll. Fung. **8**:36. 1889.
Minnesota (*Johnson*). A doubtful species.

2. **Microglossum arenarium** ROSTR. Medd. om Grönl. **3**:606. 1891.
Greenland (*Rostrup*).

3. **Microglossum elegans** (BERK.)
Leotia elegans BERK. Lond. Jour. Bot. **5**:6. 1846.
Mitrula elegans BERK. Grev. **3**:149. 1875; Hedwigia **14**:9. 1875.
"United States" (*Green*).

4. **Microglossum lutescens** (B. & C.)
Mitrula lutescens B. & C. Grev. **3**: 149. 1875; Hedwigia **14**: 9. 1875.

South Carolina (*Curtis*), New York (*Peck*).

5. **Microglossum pistillare** (B. & CKE.) SCHRŒT. in Engler-Prantl. Die natürl. Pflanzenfam. **I**: 164. 1894.
Geoglossum pistillare B. & CKE. Mycogr. 206, *pl. 96, f. 348.* 1879.
Mitrula pistillaris BERK. in Saccardo. Syll. Fung. **8**: 38. 1889.

Louisiana (*Hale*).

6. **Microglossum rufum** (SCHW.)
Geoglossum rufum Schw. Syn. fung. Am. Bor. (1831).
Mitrula rufa Sacc. Syll. Fung. **8**: 38. (1889).

New Jersey (*Schweinitz, Ellis*).

7. **Microglossum viride** (PERS.) GILL. Discom. franc. 25. 1879.
Geoglossum viride PERS. Comm. 40. 1797.
Mitrula viridis KARST. Myc. Fenn. **1**: 29. 1871.

Pennsylvania (*Everhart*), South Carolina (*Curtis*). [Europe].

8. **Microglossum vitellinum** (PERS.) SCHRŒT. in Engler-Prantl. Die natürl. Pflanzenfam **1**: 164. 1894.
Geoglossum vitellinum BRES. Fung. Frid. 41. *pl. 45, f. 1.* 1882.
Mitrula vitellina SACC. Atti Real. Inst. Venet. VI. **3**: 725. 1885.
Mitrula luteola ELLIS. Am. Nat. **17** : 192. 1883.

New Hampshire (*Farlow*), New Jersey (*Ellis*).

8a. **Microglossum vitellinum irregulare** (PK.)
Geoglossum irregulare PK. Bull. N. Y. State Mus. **1**: 28, *pl. 1, f. 5–7.* 1887.
*Mitrula vitellina *irregularis* SACC. Syll. Fung. **8**: 36. 1889.

New York (*Peck*).

III. LEPTOGLOSSUM SACC. Bot. Centralb. **18**: 214. 1884.

1. **Leptoglossum luteum** (PK.) SACC. Syll. Fung. **8**: 48. 1889.
Geoglossum luteum PK. Reg. Rep. **24**: 94, *pl. 3, f. 20–24.* 1872.

Massachusetts (*Frost*), New York (*Peck, Underwood*), New Jersey (*Ellis*), Wisconsin (*Bundy*), Minnesota (*Arthur*).

2. **Leptoglossum microsporum** (CKE. & PK.) SACC. Syll. Fung. **8**: 47. 1889.
Geoglossum microsporum CKE. & PK. in Peck. Reg. Rep. **25**: 97. 1873.

New York (*Peck*).

3. **Leptoglossum tremellosum** (CKE.) SACC. Syll. Fung. 8:47. 1889.
   Geoglossum tremellosum CKE. Mycogr. 206. *pl. 96. f. 347.* 1879.

"Amer. boreali" (*Saccardo*). Doubtfully American.

IV. MITRULA PERS. Tent. Disp. Meth. Fung. 36. 1797.

1. **Mitrula crispata** FR. Epicr. 583. 1838.
   Spathularia crispata FR. Summa Veg. Scand. 347. 1849.

New England (*Sprague*). A doubtful species.

2. **Mitrula cucullata** (BATSCH.) FR. Epicr. 384. 1838.
   Elvela cucullata BATSCH. Contr. Myc. *f. 132.* ——.
   Mitrula abietis FR. Syst. Myc. **1**:493. 1821.

New York (*Peck*), Massachusetts (*Frost*), Rhode Island (*Bennett*). [Europe].

3. **Mitrula exigua** (SCHW.) FR. Elench. **1**:235. 1830.
   Leotia exigua SCHW. Syn. Fung. Car. 1822.

North Carolina (*Schweinitz*).

4. **Mitrula gracilis** KARST. Rev. Mon. 110. 1885.

Greenland (*Rostrup*). [Europe].

5. **Mitrula phalloides** (BULL.) CHEV. Flor. Paris. 114. 1826.
   Clavaria phalloides BULL. Champ. 214. *pl. 463. f. 3.* 1789.
   Mitrula paludosa FR. Syst. Myc. **1**:491. 1822.

Massachusetts (*Frost, Farlow, Underwood*), Rhode Island (*Bennett*), New York (*Peck*), New Jersey (*Ellis*), Pennsylvania (*Schweinitz*), North Carolina (*Schweinitz, Curtis*), Alabama (*Beaumont*). [Europe].

6. **Mitrula roseola** MORG. Jour. Cinn. Soc. Nat. Hist. **18**:42, *pl. 3, f. 16.* 1895.

South Carolina (*Atkinson*).

EXCLUDED SPECIES.

Mitrula elegans BERK. Grev. **3**:149. 1879.—*Microglossum elegans.*
Mitrula inflata FR. Elench. **1**:234. 1830.—*Physalacria inflata.*
Mitrula johnsonii SACC. Syll. Fung. **8**: 36. 1889.—*Microglossum album.*
Mitrula luteola ELLIS. Am. Nat. **17**:192. 1883.—*Microglossum vitellinum.*
Mitrula lutescens B. and C. Grev. **3**:149. 1875.—*Microglossum lutescens.*
Mitrula paludosa FR. Syst. Myc. **1**:491. 1822.—*M. phalloides.*
Mitrula pistillaris BERK. in Saccardo: Syll. Fung **8**:38. 1889.—*Microglossum pistillare.*
Mitrula rufa SACC. Syll. Fung. **8**: 38. 1889—*Microglossum rufum.*

Mitrula spathulata FR. Summa Veg. Scand. 583. 1849.—*Spathularia clavata.*

Mitrula viridis KARST. Myc. Fenn. **1**: 29. 1871.—*Microglossum viride.*

Mitrula vitellina irregularis SACC. Syll. Fung. **8**: 36. 1889.—*Microglossum vitellinum irregulare.*

V. SPATHULARIA PERS. Tent. Disp. Meth. Fung. 36. 1797.

1. **Spathularia clavata** (SCHAEFF.) SACC. Michelia, **2**:77. 1880.

Elvela clavata SCHÆFF. Icon. fung. **2**: *pl. 149.* 1774.
Spathularia flavida PERS. Tent. disp. Meth. fung. 36. 1797.
Spathularia flava SWZ. Vet. Akad. Handl. 10. 1812.
Mitrula spathulata FR. Summa Veg. Scand. 583. 1849.

Maine (*Curtis*), Massachusetts (*Frost*), Connecticut (*Underwood*), New York (*Peck*), Pennsylvania (*Schweinitz*), Iowa (*Holway*), Minnesota (*Arthur*), California (*Moore*)*. [Europe].

2. **Spathularia velutipes** CKE and FARL. Grev. **12**: 37. 1883.
Vermont (*Farlow*), New Hampshire (*Farlow*).

EXCLUDED SPECIES.

Spathularia inflata (SCHW.) CKE. Mycogr. 204. *pl. 395. f. 44.* 1879. —*Physalacria inflata.*

VI. LEOTIA FR. Syst. Myc. 2: 29. 1822. [Ex. *Hill.* Hist. Pl. 43. 1751.]

1. **Leotia chlorocephala** SCHW. Syn. fung. Car. 88. 1822.
Massachusetts (*Frost*), Connecticut (*Underwood*), Pennsylvania (*Michener*), North Carolina (*Schweinitz, Curtis*), South Carolina (*Curtis*), Florida (*Calkins*).

2. **Leotia lubrica** (SCOP.) PERS. Syn. Meth. fung. 613. 1801.

Leotia gelatinosa HILL. Hist. Pl. 43 1751.
Elvela lubrica SCOP. Fl. Carn. **2**: 477. 1772.
Helvella gelatinosa BULL. Champ. Franc. 296. *pl. 473. f. 2.* 1786.

Massachusetts (*Hitchcock, Frost, Underwood*), Connecticut (*Underwood*), Rhode Island (*Bennett*), New York (*Peck*), New Jersey (*Ellis*), Pennsylvania (*Schweinitz*), North Carolina (*Schweinitz, Curtis*), Iowa (*Holway*), Wisconsin (*Bundy*). [Europe].

3. **Leotia ochroleuca** CKE. et HARK. Grev. **9**: 8. 1880.
California (*Harkness*).

4. **Leotia rufa** ROSTR. Medd. om Grönl. **3** : 536. 1888.
Greenland (*Rostrup*).

*Reported as var. californica Moore, name only.

5. **Leotia stipitata** (Bosc) Schroet. in Engler-Prantl: Die natürl. Pflanzenfam. **1**:166. 1894.

Tremella stipitata Bosc, Berl. Mag. naturf. 89. *pl. 6. f. 14.* 1811.
Leotia viscosa Fr. Syst. Myc. **2**: 30. 1822.

Pennsylvania (*Schweinitz*), North Carolina (*Schweinitz, Curtis*), South Carolina (*Ravenel*).

EXCLUDED SPECIES.

Leotia brunneola B. and Br. is from Ceylon; erroneously reported from Cuba in Saccardo: Syll. Fung. **8**: 611.
Leotia circinans Pers. Icon. et Descr. fung. 16. *pl. 5. f. 5-7.* 1798.—*Cudonia circinans.*
Leotia elegans Berk. Lond. Jour. Bot. **5**:6. 1846.—*Microglossum elegans.*
Leotia exigua Schw. Syn. fung. Car. 1822—*Mitrula exigua.*
Leotia gelatinosa Hill. Hist. Pl. 43. 1751.—*L. lubrica.*
Leotia inflata Schw. Syn. fung. Car. 1822.—*Physalacria inflata.*
Leotia marcida Pers. Syn. fung. 613. 1801.—*Cudoniella marcida.*
Leotia truncorum A. and S. Consp. fung. Nisk. 297. 1805.—*Vibrissea truncorum.*
Leotia viscosa Fr. Syst. Myc. **2**:30. 1822.—*L. stipitata.*

VII. CUDONIELLA Sacc. Syll. Fung. 8:41. 1889.

1. **Cudoniella fructigena** Rostr. Medd. om Grönl. **3** : 605. 1891.

Greenland (*Rostrup*).

2. **Cudoniella marcida** (Müll.) Sacc. Syll. Fung. **8**:41. 1889.

Phallus marcidus Muell. Fl. Dan. *pl. 654. f. 1.* 1770.
Leotia marcida Pers. Syn. fung. 613. 1801.

New York (*Peck*). [Europe].

VIII. CUDONIA Fr. Summa Veg. Scand. 348. 1849.

1. **Cudonia circinans** (Pers.) Fr. Summa Veg. Scand. 348. 1849.

Leotia circinans Pers. Icon. et Descr. Fung. 16. *pl. 5. f. 5–7.* 1798

New York (*Peck*), North Carolina (*Schweinitz, Curtis*). [Europe].

2. **Cudonia lutea** (Pk.) Sacc. Atti Real. Inst. Venet. VI. **3**:725. 1885.

Vibrissea lutea Pk. Reg. Rep. **25**: 97. *pl. 1. f. 19–23.* 1873.

New York (*Peck*), Massachusetts (*Frost*).

IX. VIBRISSEA Fr. Syst. Myc. 2:31. 1822.

1. **Vibrissea truncorum** (A. & S.) Fr. Syst. Myc. **2**:31. 1822.
Leotia truncorum A. & S. Consp. fung. Nisk. 297. *pl. 3. f. 2.* 1805.

New Hampshire (*Farlow*), Massachusetts (*Frost*), New York (*Peck*), New Jersey (*Ellis*), North Carolina (*Schweinitz*), California (*Harkness*).

1a. **Vibrissea truncorum albipes** PK. Reg. Rep. **44**: 37. 1891.

New York (*Peck*).

EXCLUDED SPECIES.

Vibrissea lutea PK. Reg. Rep. **25**: 97. 1873.—*Cudonia lutea.*
Vibrissea turbinata PHILLIPS. Trans. Linn. Soc. **2**: 10. 1881.—*Gorgoniceps turbinata.*

RHIZINACEÆ.

I. RHIZINA FRIES. Obs. Mycol. 1: 161. 1815.

1. **Rhizina inflata** (SCHAEFF.) KARST. Rev. Mon. 112. 1885.

Elvela inflata SCHAEFF. Fung. Bav. et Palat. Icon. *pl. 153.* 1774.
Rhizina undulata FR. Obs. Mycol. **1**: 161. 1815.
Helvella acaulis PERS. Syn. fung. 614. 1801.

Connecticut (*Thaxter*) New York (*Peck*), Rhode Island (*Bennett*), Pennsylvania (*Schweinitz*), Wisconsin (*Bundy*) North Carolina (*Curtis*), South Carolina (*Curtis*).

2. **Rhizina spongiosa** B. & C. Jour. Linn. Soc. **10**: 364. 1869.

Cuba (*Wright*).

II. PSILOPEZIA BERK. Lond. Jour. Bot. 6: 325. 1847.

1. **Psilopezia flavida** B. & C. Grev. **4**: 1. 1875.
Alabama (*Peters*).

2. **Psilopezia mirabilis** B. & C. Jour. Linn. Soc. **10**: 364. 1869.

Cuba (*Wright*).

3. **Psilopezia nummularis** BERK. Lond. Jour. Bot. **6**: 325. 1847.

New York (*Peck, Ellis, Underwood*), Pennsylvania (*Michener*), Ohio (*Lea*), Indiana (*Underwood*), North Carolina (*Curtis*), South Carolina (*Curtis*).

III. UNDERWOODIA PECK. Reg. Rep. 43: 32. 1890.

1. **Underwoodia columnaris** PECK. Reg. Rep. **43**: 32. *pl. 4 f. 1–4.* 1890.

New York (*Fischer, Underwood*).

Auburn, Alabama, 1 February, 1896.

XXX. A CONTRIBUTION TO THE PHYSIOLOGY OF THE ROOT TUBERS OF ISOPYRUM BITERNATUM (RAF.) TORR AND GRAY.

D. T. MacDougal.

Isopyrum biternatum is found in North America northward from Florida and Kentucky and eastward from the Rocky mountains. It reaches its best development in a moist leaf mould or coarse sandy alluvial soil on northern slopes and shaded ravines near the margin of deciduous forests. The vegetative body of the plant consists of a thickened branching, woody perennial rhizome with closely crowded internodes, from which depends a dense tangle of fibrous roots. Arising from the rhizome are a number of annual smooth, slender stems 11 to 20 centimeters in height, on which are borne the 2 or 3 ternately compound leaves, and the axillary (Gray XV.) flowers. The roots penetrate the soil to a depth of 10 or 15 centimeters and to an equal distance laterally. They are characterized by Asa Gray (III) as "thickened here and there into small tubers." The rhizomes die away in the older portions as they extend in length, so that the attached roots may attain an age of two or three years. A few biternate leaves in a functionally active condition are present during the entire winter; the seasonal vegetative period begins when the soil reaches—5° to 3° C., and continues 80 to 110 days—March-June—according to the latitude. The greatest leaf area is exposed during May and June. The small anemone-like flowers appear during April—June, each lasting two or three days. The seeds mature in June and since no seedlings have been found around the old plants in the autumn, and seeds placed in the soil in the plant house did not germinate until five months later, it seems safe to conclude that their latent period ordinarily extends through the winter following maturity. In the autumn the rhizomes send out numerous runners which serve as a very effectual means of propagation. The general aspect of the adult plant may be seen in Plate 28 and Fig. 1. Pl. 29, and the seedling in Fig. 10 Pl. 29.

My attention was first called to the somewhat peculiar features of the anatomy of the tubers in 1888 and since that time I have had the plant under more or less continual observation in the botanical laboratories of De Pauw and Purdue Universities, the State University of Minnesota, and the Botanic Institute, Leipsic, as well as in the natural habitats of the plant, with the result that some noteworthy features of the mechanisn of protection and storage of reserve material have been brought to light.

Anatomy of roots and tubers. The long slender roots are closely crowded together at the point of origin on the internodes of the rhizome, and since they penetrate a loose friable moist soil, are only slightly geotropic, and grow very slowly with but little expenditure of outward work in the way of external pressure. As a natural accompaniment of this method of growth, only a rudimentary root cap has been developed and the zone of root hairs extends to within 1 or 2 millimeters of the tip.

In a discussion of the features of the morphology of the roots of the Ranunculaceae, Mr. Maxwell (VIII) has without examination classed the roots of Isopyrum among those of tetrarchic formation. It is seen, however, to be diarchic (Fig. 2, Pl. 29). The formation of the secondary hadrome and differentiation of the endodermis only slightly precedes the development of the root-hair cylinders of the piliferous layer. It has been observed that in some instances the formation of the tuber began simultaneously with, or immediately following the appearance of the secondary hadrome, and previous to the formation of the root-hairs, although it does not usually begin until some time later—a fact which accounts for great differences in the cortex of the mature tuber. The secondary hadrome is formed from the arches of meristematic tissue lying between the two groups of primary vessels, and the lateral vessels of the secondary hadrome border directly on the innermost vessels of the primary hadrome, both in normally thickened roots and in tubers, thus forming an irregular ring.

The formation of a tuber consists primarily in the exaggerated external development of the pericycle, which retains in greater part its meristematic character even in old tubers, coupled with a co-ordinate extension of the cambiform rays (*assise génératice* of Van Tieghem XIV) Fig. 4 Pl. 29 which enforce tangential growth in the endodermis and cortex. The mass of cells formed from the pericycle are entirely without intercellular spaces. The nuclei of these cells lie in the lining

layer, and are most delicately sensitive to the metabolic conditions prevalent in the cell, to which they respond by changes in size, form and structure. These cells serve for the storage of reserve food—principally carbohydrates as will be described below. The tension of the expanding tissue derived from the pericycle induces a tangential expansion of both endodermis and cortex. In the endodermis this has been accomplished by radial longitudinal division, and in many of the cells three or four secondary walls have been formed. The cortex which in normal roots may attain a thickness of 8 to 12 layers, in the tubers is rarely more than 4 to 6 in thickness, due to the expansion in a tangential direction. In both cortex and endodermis the secondary can be distinguished from the primary walls by their non-suberization. The division of the cortex is not so regular as in the endodermis, and portions of the outer layers are lost by decay. In some instances patches of the piliferous layer remain. The endodermis and outer layers of cortex contain large pale gray and yellowish brown globules and masses whose composition will form the subject of a separate paragraph. The rays extending outwardly from the secondary tissues, reach one-half to two-thirds of the distance to the endodermis, and are composed of cambiform cells which are clearly meristematic except in some instances at the outer edge where in a small group the protoplasmic content has been partially lost, the walls thickened and pitted and a trace of lignification has appeared. The rays comprise two or four layers of cells, which in the more external portions exhibit a greater radial than tangential diameter. The parenchymatous tissue lying in the plane of the rays exhibits a radial arrangement similar to that of the rays. In the thickenings of the roots of Isopyrum trifoliatum which are triarchic, similar wedge-shaped extensions of cambium tissue occur, and one or more vessels may be formed at the outer edge of the ray. When the formation of a tuber occurs in a portion of a root from which a branch arises, the thickening entails a disposition of the tissues which is most clearly seen by reference to Fig. 11 Pl. 29. The thickened woody nature of the cells at the outer edge of the ray is preserved in the lateral converging branches.

In I. biternatum the small mechanical value of the woody elements is supplemented by the high degree of turgidity of the comparatively large mass of storage tissue; a turgidity resulting in part from the high osmotic coefficient of the contained sugars, but maintained even when free from reserve

substance by the acid content. Thus the state of firmness and plumpness of the tubers offers no indication of the presence or absence of carbohydrates.

So far as I have been able to examine other species of this genus the amount of development of the secondary and tertiary woody tissue in the storage organs is in proportion to the tendency to convert the carbohydrates into solid form, and thus decrease the turgidity of the parenchymatous cells. It is of course to be admitted that other factors influence the development of woody tissues in root formations, but in such tubers as those of I. biternatum the mechanical strains to be borne by the roots are very slight.

Outwardly the tubers are more or less irregular globoid or cylindrical thickenings of the roots which may attain a diameter of 5 mm. or about three times the diameter of a normal root and the thickening may extend a distance of 2.5 cm. along the root. The metamorphosis of a root into a tuber may begin a few centimeters from the tip and a constant increase in size takes place during the entire life of the root—one to three years. On seedlings the thickening begins in 60 to 70 days after germination of the seed, when only three or four foliage leaves had appeared. The first outward indication of the change is the glistening silvery white appearance of the portion of the root concerned.

In a brief description of the anatomy of the tubers Professor C.W. Hargitt(V) has noted that the mass of the tuber was due to the accented development of the conjunctive parenchyma, and also concluded that these cells contained inulin and that the "subepidermal" tissue contained aleurone. I have been unable to confirm this diagnosis as to the reserve material, and must also reject my former conclusion (XXII) that the tubers are not storage organs, a conclusion to which I was led by the early stage in the development of the root in which tuberous thickening might begin, their behavior when free from surplus food and the presence of a mycelium infecting the outer layers of several lots of material examined.

It has been determined that the presence of this organism is purely incidental and in a few instances only has it penetrated farther than the endodermis.

Reserve material. In the work upon the character and sequence of the reserve substances from 1888 to 1893 only material taken from the natural habitat under entirely natural con-

ditions was used, but since the latter date I have had an ample supply of material under constant observation in the plant houses.

In the determination of the contents of the storage cells of the tuber the following reactions were obtained from September to May—during the winter resting period of plants under natural conditions.

If sections of a tuber freshly detached from the plant were mounted in a drop of strong alcohol, the parenchyma cells were almost instantly filled with numerous small globules which appeared pale gray tinged with violet. An immense number of these globules might also be observed in the fluid surrounding the sections. If a drop of water were placed at the edge of the cover glass the globules instantly disappeared, and if the slide were allowed to remain in the open air a few hours the water absorbed from the air and extracted from the walls was sufficient to dilute the alcohol to such a point that the globules were dissolved. A series of tests with a number of solutions of alcohol revealed the fact that the globules were formed as above with all solutions of alcohol above 80 per cent. by volume but with the use of a 75 per cent. solution the globules were not formed so quickly and were redissolved in a few minutes. With 70 and 65 per cent. solutions the globules were slowly formed to disappear soon by an instantaneous breaking down. In a 60 per cent. solution no globules were formed. This globular formation on the addition of strong alcohol was first described by Kraus (VI) as seen in the sugar beet and was supposed by him to be indicative of the presence of sucrose; but it is possible that the globules might consist partially of reffinose or secalose (XIII). If the sugar laden cells were kept under observation when the drop of alcohol was allowed to act from one side, the globules might be seen forming against the cell wall through which the alcohol entered and being carried with the current toward the center of the cell, where the first ones were dissolved owing to the great proportion of water present here. With the saturation of the cell sap with alcohol, the sugar was again thrown down and finally the cells would be almost entirely filled with the globules which reached a size equal to one-tenth the diameter of the cell or were barely visible points (Fig. 4, Pl. 29). In Kraus' reactions the globules were seen to disappear briefly, doubtless owing to the gradual dilution of the alcohol as above described. In the material under examination, however, if the alcohol were re-

newed and kept free from water, the globules remained intact. Sections containing the globules were placed in a small amount of alcohol (95 per cent.) for ten days and were unchanged. After 100 days in absolute alcohol the globules had taken on a firmer consistency, and an ovoid, or irregular form (See Pl. 29 Fig. 4). In the ovoid and globoid forms an appearance of stratification could be detected, but no exact determination could be made. From time to time fusion of two or more of the globules in freshly treated sections occurred, and this fusion was greatly facilitated by warming to 50° C. Although Kraus obtained globules in the sugar laden cells on the addition of glycerine, the test was scarcely successful in Isopyrum. Only a few lumpy aggregations against the walls of the parenchymatous cells might be seen. Further if strong alcohol were added to the preparation the globules were formed in great numbers outside of the cells showing the dialyzation of the sugar by the glycerine. Ether and chloroform caused no reaction in the cells, although in sections remaining in these fluids the globules previously formed were fused by their mechanical action in the extraction of the alcohol. Solutions of iodine gave no decided reaction either on the cell sap or on the globules. In order to determine the presence or absence of a membrane of precipitation on the globules formed by alcohol, Congo-red and a number of aniline stains were applied but no such formation could be found. An extract obtained by macerating 100 grams of fresh tubers taken from the soil in April, showed an active sugar which turned the plane of polarization to the right. On the addition of a mineral acid the sugar became inactive. This and the marked reaction obtained in the red color resulting from the use of thymol and sulphuric acid both on fresh sections and the extract indicated a large proportion of sugar present. Sections of tuber placed in solution of methylene blue in absolute alcohol gave the usual aggregation which, however, contained none of the coloring matter. When placed in a weak solution of caffein in water a small amount of plasmolysis was observable in the meristematic cells but no aggregation of any sort in the reserve laden parenchyma. On the addition of strong alcohol to the sections thus treated the globules were formed in the usual manner.

The tubers gave a strong acid reaction which was found to be due to the presence of a complex organic acid for which no test was available. This acid seemed to be uniformly present

and might account for the turgidity of the parenchyma and consequent plumpness of the tubers even when devoid of stored sugars. In tubers taken from plants in the open from May to August many of the leucoplasts surrounding the nuclei in the storage cells as well as in the cortex contained a simple polyhedral or globoid granule, which gave reactions similar to the "red starch" of Nägeli which has recently been so thoroughly exploited by A. Meyer (X). The formation of granules in the leucoplasts occurred in plants in the open air in the spring in about sixty days from the beginning of the vegetative season and the expansion of the chlorophyll area. Plants taken from the soil September 31st and placed in a green house at a temperature from 15° to 28° C., soon awakened from their dormant condition, began the expansion of the chlorophyll bearing area, and forty days later the formation of reproductive bodies and fifty days later granules appeared in the tubers. In the latter instance the plant had received an amount of illumination about equal in value to that of the first, and perhaps a greater number of heat units. Freshly cut sections placed in iodine water gave the granules a light dingy blue, slightly tinged with brown. Other sections allowed to remain 15 hours in the solution gave a deeper shade of the same tints. In either case they faded if allowed to remain in distilled water after washing. On the addition of dilute chlor-zinc iodine to a section the granules became first a decided blue, passing gradually into a brown and finally into a reddish brown, which gradually faded if the iodine were washed out with water. Treatment of sections left in diastase for 24 hours resulted in the corrosion and almost total disintegration of the granules, but a large number of the cells of the cortex and parenchyma were filled with masses coloring reddish violet on the addition of potassium iodide-iodine, which by A. Meyer's interpretation indicates the presence of a remnant of the granules consisting of *a* amylose and amylodextrin. On treatment with boiling water for a few seconds the granules were swollen, the outer skeleton was distinctly visible and remained unstained on the addition of potassium-iodide-iodine, while a portion of the inner mass was dissolved away. On lengthened treatment with boiling water to 100 seconds the entire granule was disintegrated, inclusive of the colorless skeleton. The granules remained unchanged during several days exposure to cold alkalies but were quickly broken down if the solution were raised to 100° C. On saturation with sulphuric acid and subsequent treatment with iodine a blue color

resulted. In cells containing the "red starch" granules a copper reducing substance—a carbohydrate—is to be found during the entire year.

The mesophyll cells of the leaves after a period of activity of the chlorophyll, contained a substance, which by its reaction to iodine, must have consisted largely of amylodextrin, and during the period of maximum activity, solid masses were to be found in the leucoplasts similar to those in the tubers. Only in such instance was a copper reducing sugar found and in small quantity in the mesophyll cells. It would appear by inference that the ultimate product of the synthetic process in the mesophyll is sucrose, that the surplus supply is converted into a starch different only from the ordinary forms by the proportions of *a* amylose and *B* amylose, and that the form taken in translocation is probably maltose, or some copper reducing sugar since this form was present from the leaves to the tubers and in greatest quantity in the conducting cells. This is further confirmed by the fact that in detached portions of rhizomes and tubers the amount of copper reducing sugar was sensibly diminished and as the amount of cane sugar increased. The same was also true of tubers placed in a 5 per cent. solution of cane sugar.

A similar scarcity of copper reducing sugar was noted in tubers in which the formation of red starch granules was begun. As for the physiological conditions which lead to the condensation of the sugars into starch granules containing large proportions of amylodextrin and in consequence reacting reddish brown to iodine, nothing exact can be given. Since the amylodextrin is formed from amylose by diastatic action it seems entirely possible that such starch granules indicate a constant and strong action of the ferment during the process of condensation, a view confirmed by the constant presence, during both the resting and actively vegetative period, of large proportions of a diastatic ferment in the storage cells.

When sections of a tuber were mounted in water and a crystal of ammonium tartrate placed at the edge of the cover and allowed to dissolve there were formed large globules nearly filling the parenchymatous cell cavities. When fresh sections of the tuber were placed in alcohol-tartaric acid solution, a globular aggregation of granular or radial structure was formed in the perfect cells, but in those which had been mechanically torn or injured, a number of crystals of rhombic form of the hexagonal system with angles, incomplete or obscure. In a

few of the intact cells, in the injured ones, and in the fluid around were a number of radially arranged groups of slender or needle shaped incomplete crystals. These crystals are easily soluble in water, insoluble in alcohol and acetic acid, and must have been mixtures of bitartrate of potassium and calcium (IV, p. 56). In a farther differentiative test of crystal of ammonium oxalate placed at the edge of a cover glass diffused through the water in which the section was mounted forming a great number of tetragonal pyramidal and monosymmetric rhombohedral forms. Ammonium carbonate gave a similarly marked reaction, and if a drop of sulphuric acid were added to the ash a plentiful supply of gypsum needles were formed. The calcium occurs also in occasional crystals of the oxalate in the stems and rhizomes. Treatment of the ash of tubers with platinum bichloride gave a large number of the characteristic crystal forms of potassium-platinum-chloride. On the addition of a solution of sodium phosphate containing a trace of ammonia to the ash of tubers a moderate amount of ammonium-magnesium-phosphate crystals were formed.

Calcium was found somewhat evenly distributed through the parenchyma of the tubers and in a large proportion of the cortex of the same. In the leaves the greatest amounts were found in the conducting sheaths of the fibro-vascular tissue, and in the epidermal cells of the entire organ in great plenty. The application of the platinum bichloride test to leaf stalks shows also a very large amount of potassium in the leaf lamina. While no quantitative determinations could be made it was apparent that the amount of this substance steadily increased from the root-tubers to the leaves. The amount of magnesium present in the leaf, stem, and tuber showed no great variation, though doubtless an exact determination would reveal distinct differences.

With a view to the possible discovery of the conditions, which determine the formation of "red starch" recourse was had to the methods of Godlewski (II), Boehm (I), Schimper (XII), Meyer (IX) and Rendle (XI). In these tests chlorophyll-bearing areas of the plant were exposed to atmospheres containing proportions of carbon dioxide from the normal to 25 per cent. and at the same time, or separately to solutions of cane sugar varying in strength from 5 per cent. to saturation. The tubers and other tracts containing colorless chromatophores were placed in solutions of cane sugar glycerine, glucose, glycogen, asparagin, etc.

In the exposure of chlorophyll bearing organs of the plants to atmospheres with increased carbon dioxide content, it was found that in all proportions below 25 per cent. the mesophyll cells and guard cells of the stomata contained an unusually large amount of some substance reacting reddish brown with potassium-iodide-iodine, and by farther exposure the chloroplasts became distended and filled with apparently solid masses of similar substance. Similar formations were to be seen in the leucoplasts of the parenchyma, lateral to the mestome areas in the stems. Effects similar to the above were also secured by placing excised leaves in 5-10 per cent. sugar solutions for 40 hours and the general results in no wise differ materially from those reached by exposure of plants to maximum insolation. In stems which had lain in a 5 per cent. solution for a week, the parenchymatous elements in immediate contact with the bundles held large amounts of granules which on treatment with potassium hydrate and iodine gave a dingy purple color; in 20 per cent. solution one week a small number of solid red bodies in the mesophyll of stem with iodine solution. In tubers placed in the 5 per cent. solution for a week, granules were formed which in every way reacted and had the appearance of those regularly appearing at the beginning of the vegetative season. In the 10 per cent. solution the formation of granules was not more marked than in the 5 per cent. solution. From 5 to 10 per cent. was the most favorable concentration for the formation of starch from sugar.

In tubers which had lain in 5 per cent. solution of cane sugar 10 days the number and size of the leucoplasts and of red starch granules had increased while the nuclei were almost double their former size. Not only were the leucoplasts containing red starch found plentifully in the parenchymatous cells and the meristem rays, but also in all but the outer layer of the cortex as well as the endodermis. In one instance four small granules of similar reaction were unmistakably seen in the nucleus impinging on the nucleolus. A tuber which had lain in a ten per cent. solution of glycerine 50 hours had formed a large number of red starch granules in the parenchymatous cells. It had not effected any changes in a stem in 70 hours however.

In order to test the effect of calcium and potassium salts on the translocation and condensation of the carbohydrates tubers with one end cut away were placed in the nitrates of these substances in solution, which contained in one instance 1 per cent.

and in the other $\frac{1}{4}$ per cent. of the salt. Four days later in the 1 per cent. solutions only occasional starch bodies were found. In the $\frac{1}{4}$ per cent. solution of both substances numerous granules were formed. In both these instances the nucleus seemed extraordinarily large and ragged in outline after treatment with potassium-iodide-iodine. Many similar experiments show beyond doubt that in proportions as great as 1 per cent. these salts hinder the condensation of the carbohydrates. The influence upon the translocation and absorption of the sugar solution, appeared to be the same in the use of both substances. Since the cells in the beginning of the feeding experiments were almost saturated with sugar, however, it appears that the influence of the stronger solution is such as to inhibit the condensation of the sugars, most probably by changes brought about in them in the acid content.

Contents of external tissues. The sap of the epidermal cells of the stems, leaves, the endoderm and certain cell of the cortex contains a bitter tasting substance which on the application of potassium-iodide-iodine forms a globular mass or meshwork of aggregations or precipitations reddish brown in color. Washed with water and mounted in glycerine, the color soon fades to a light reddish or yellowish brown. The guard cells of the stomata of the leaves and stems contain a substance which colors a more darkly reddish brown on the addition of the iodine solution, which after washing and mounting in glycerine fades entirely. The original color of both surface and guard cells may be obtained if the glycerine is replaced by water and iodine added as before. The addition of iodine in 96 per cent. alcohol gives a precipitate in the epidermal cells somewhat brighter in color than is obtained by the use of potassium-iodide-iodine, while the guard cells react as before. If such sections are left in alcohol over night the color disappears entirely, and the absence of reaction when a fresh solution of iodine is added shows that the substance precipitated has been dissolved in alcohol. In stems which had lain in alcohol for 5 months no trace of this substance could be found, it having been extracted by the fluid. By the use of iodine in water a dull yellowish precipitate was obtained. The precipitate obtained with potassium-iodide-iodine is insoluble in phosphoric, and hydrochloric acids when added in the form of a drop at the edge of the cover glass. Nitric acid, however, causes the precipitate to take the form of irregular jagged

masses or octahedral or needle shaped crystals all of which appear black in transmitted light.

If epidermal sections of the leaves were placed in a solution of 1 part tartaric acid in 20 parts absolute alcohol for two hours, there appeared inside the cells a number of globular aggregations of a granular or in some cases radial structure. Later in some of the cells these were broken up and were replaced by radially arranged bundles of crystals similar to those in the tuber which were not dissolved in 95 per cent. alcohol in 30 days. When a cell containing these aggregations was disturbed by crushing the process was hastened. If untreated sections were placed in a Mayer's solution of potassic-mercuric-iodide, a whitish granular precipitate was formed in the mount, partly inside the cells but for the greater part in the fluid in contact with them, or their inner walls. This precipitate was insoluble in alcohol, and weak and strong hydrochloric acid. A small amount of the potassic-mercuric-iodide precipitate was also formed in the outer layers of the cortex in the tubers.

So far as the above and the reactions with the alkaline carbonates are capable of interpretation, it would appear that there is present in the sap of the external tissues of the leaves and stems some form of tannin and a chromogen from which the characteristic red color of the leaves may arise. In addition the cells of the outer layers of the cortex of the tubers contained one or more pale grayish globules (Fig. 8, Pl. 29) whose diameter may be nearly equal to that of the cell. They are to be found as well in a large proportion of the cells of the external tissue in all parts of the root to within 1 or 2 mm. of the tip. These globules are immediately soluble in alcohol, slowly soluble in either, and take on an eosin red coloration on treatment of fresh material with chrom-acetic-osmic-acid, finally becoming black. If sections treated with potassium-iodide-iodine are placed in 95 per cent. alcohol for 48 hours the globules will disappear entirely except at certain places in the outer layer of the cortex where a few retain their form, size and the characteristic reddish brown coloration. These globules take on a red color in a solution of alkannin, and appear to belong to the fatty oils. Similar globules are to be found in the outer layers of the tubers of Isopyrum adoxoides. In a number of the outer cells are to be found pale yellowish masses or aggregations of rounded granules which are insoluble in cold alcohol

but dissolve on boiling, and are dissolved with difficulty by concentrated solutions of chloral hydrate, and may be regarded as of a waxy nature.

The tubers as well as the roots of I. biternatum are often thickly invested with a non-septate mycelium which penetrates the outer layer of the cortex by means of haustorial branches (Fig. 8, Pl. 29). Only in rare instances has the tuber been found to have been more deeply penetrated by the filaments, and in the many thousands which have been examined none have shown indications of injury from animals. The tubers have a pungent, slightly bitter taste, and the presumption seems entirely warranted that the tannin in the cell sap or the oily substance in the outer tissues may serve as a means of protection.

A lot of tubers obtained October 10, 1894, weighing 2.8 grams gave .505 grams residue when dried over a water bath at 100° C. for 24 hours. A second lot taken from the soil April 11, 1895, weighing 8.74 grams gave 1.923 grams of residue and 6.817 grams of water. An ether extract, using the Soxhlet apparatus, of the residue of the first lot amounted to 3 mg.

Water cultures. Several small plants not yet a year old were placed in water culture jars filled with a solution of nutritive salts in river water on October 15, 1894. These plants lived, bloomed and sustained normal appearances until June, 1895, although no doubt considerably weakened since they were unable to form perfect seeds. In order to furnish these plants with a normal degree of root temperature the culture jars were imbedded in the soil of a box 20 cm. x 20. cm. x 1 meter. The soil in the box received the usual daily watering of the green house. The new water roots formed on these plants produced a lessened amount of mechanical tissue and developed only rudimentary root hairs. In several instances these roots began to show evidence of the thickening usually preliminary to the formation of tubers.

Recapitulation. As a summary of the foregoing it may be stated that:

1. The tubers are formed by an excessive development of the pericycle which may begin contemporaneously or following the formation of the secondary tissues of the root, and that the consequent enlargement is accompanied by an enforced tangential development of the cortex and endodermis and a radial development of the cambium.

2. A compensation for the low value of the mechanical elements in the elongated tubers is furnished by the habit of

the root in penetrating a loose substratum, and the relatively high osmotic coefficient of the acid content of the storage cells. As species of this genus exhibit a tendency to condense reserve carbohydrates into solid form, and lower the acid content, the mechanical elements increase in value.

3. The product of the photosynthetic action of the leaves is probably cane sugar, which in case of surplus accumulation is converted into a form reacting reddish brown to iodine solutions. During translocation it assumes the form of a copper reducing substance, and accumulates in the tubers as cane sugar. During the season of greatest chlorophyll activity a portion of the cane sugar is condensed into the form of "red starch" by the leucoplasts surrounding the nucleus. The starch disappears on the formation of the propagative shoots, in autumn.

4. The tendency to form "red starch" is characteristic and may not be altered by exposure to high proportions of carbon dioxide, feeding with carbohydrates, or condensation by glycerine.

5. No connection could be traced between the distribution of the mineral salts, except calcium, and the carbohydrates. The presence of 1 per cent. of calcium or potassium nitrate in a sugar solution will inhibit its condensation into starch.

6. The tendency to form tubers on the roots seems firmly fixed, and such formation occurred in water cultures in an apparently starving condition.

7. The sap of the external tissues contains a bitter tasting substance and in addition the outer cortical cells of the roots and tubers contain large drops of oil. These substances may subserve as a means of protection, since no plants have been observed to have been injured by animals, and only in rare instances has the investing mycelium penetrated the tuber, by means of its haustorial branches, as far as the endodermis.

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EXPLANATION OF PLATES.

PLATE XXVIII.

Isopyrum biternatum with flowers and seed capsules.

PLATE XXIX.

Anatomy of Isopyrum biternatum.

Fig. 1. Cross section of tuber. X 100.
- *a.* Cortex.
- *b.* Endodermis.
- *c.* Meristematic arch.
- *d d.* Rays of meristematic tissue.
- *e e.* Secondary hadrome.
- *f f.* Primary hadrome.

Fig. 2. Parenchyma cell showing leucoplasts containing starch grains at time of flowering. X 450.

Fig. 3. Parenchyma cell with nucleus covered by layer of starch grains at time of maturity of seeds. X 450.

Fig. 4. Parenchyma cell taken from tuber grown in plant house during December. Treated with absolute alcohol for 100 days. X 450.

Fig. 5. Parenchyma cell taken from tuber in February. Freshly treated with absolute alcohol. X 450.

Fig. 6. Cross section of root 3 mm. from tip. X 700.
- *c.* Endodermis.
- *b.* Primary hadrome.
- *a.* Group of cells from which secondary hadrome arises.

Fig. 7. Plant 4 months old.
- *a.* Tubers, ½ natural size.

Fig. 8. Surface section of tuber. X 450.
- *a.* Oil drops.
- *b.* Hypha.

Fig. 9. Root thickened into tuber. X 10.

Fig. 10. Seedling.
- *a.* Cotyledon. X 12.
- *c.* First foliage leaf.
- *b.* Second foliage leaf.
- *d.* Third foliage leaf.

Fig. 11. Diagram showing disposition of tissues in branch of tuber.
- *c.* Primary hadrome.
- *b.* Secondary hadrome.
- *a.* Endodermis.

XXXI. DETERMINATIONS OF PLANTS COLLECTED BY DR. J. H. SANDBERG, IN NORTHERN MINNESOTA, DURING 1891.

J. M. HOLZINGER.

[The plants listed below were collected by Dr. J. H. Sandberg, under commission from the U. S. Dept. of Agriculture. The determination of them was carried on by Mr. J. M. Holzinger while assistant botanist in the National Herbarium. Dr. George Vasey, at that time Chief of the Division of Botany at Washington, expressed a willingness to have the report printed by the Minnesota Survey, and Mr. F. V. Coville, present Chief of the Division of Botany, has ratified the wish of Dr. Vasey by turning the MS. over to Mr. Holzinger for publication in MINNESOTA BOTANICAL STUDIES. The collections here listed were made over that part of the state extending between the western end of Lake Superior and the lake Itasca region, covering the southern portions of the counties of Lake, St. Louis and Itasca, and portions of the counties of Carlton, Aitkin, Cass, Crow Wing and Morrison. Smaller collections made in the counties of Hennepin, Ramsey, Goodhue and Chisago are also included. The list as a whole is highly valuable as giving a good idea of the plant population established around the head waters of the Mississippi. By the purchase during the present year of Dr. J. H. Sandberg's entire collection, the duplicates of most of the plants listed here have been added to the Minnesota collections of the Survey. The rest are on file in the cases of the National Herbarium.—*Editor.*]

LYCOPODIACEAE.

Lycopodium clavatum L. Sp. Pl. 1101. 1753.
Woods. Thompson. July. No. 427.

Lycopodium complanatum L. Sp. Pl. 1104. 1753.
Woods and spruce swamps. Thompson; Two Harbors; lake Itasca. July. Nos. 429, 465, 1245.

Lycopodium obscurum L. Sp. Pl. 1102. 1753.
Woods. Thompson. July. No. 428.

SELAGINELLACEAE.

Selaginella rupestris (L.) SPRENG. Mart. Fl. Bras. **1**: Pt. 2. 118. 1840.
Slate rocks. N. P. Junction. June. No. 254.

OPHIOGLOSSACEAE.

Botrychium lunaria (L.) SWARTZ. Schrad. Jour. Bot. **2**:110. 1800.

Wet rocky woods. Two Harbors. July. No. 438.

Botrychium ternatum (THUNB.) SWARTZ. var. **australe** GRAY.

Woods. Grand Rapids. August. No. 437.

Botrychium virginianum (L). SWARTZ. Schrad. Jour. Bot. **2**:111. 1800.

Rich woods and shady banks. Thompson; lake Itasca. July. Nos. 560, 1147.

EQUISETACEAE.

Equisetum robustum A. BR. Engelm. Am. Jour. Sci. **46**:88. 1844.

Springy, sandy places. Thompson. June. No. 138.

Equisetum scirpoides MICHX. Fl. Bor. Am. **2**:281. 1803.
Along streams. Lake Itasca. July. No. 1150.

Equisetum sylvaticum L. Sp. Pl. 1061. 1753.
Wet ground. Thompson. May. No. 62.

Equisetum variegatum SCHLEICH. Cat. Pl. Helv. 27. 1807.
Deep ravines. Thompson. May. No. 91.

FILICES.

Pellaea atropurpurea (L.) LINK. Fil. Hort. Berl. 59. 1841.
Sandy cliffs. Cannon Falls. July. No. 379.

Asplenium filix-foemina (L.) BERNH. Schrad. Neues Jour. Bot. **1**: Pt. 2. 26. 1806.

Copses. Two Harbors. August. No. 896.

Phegopteris dryopteris (L.) FEE. Gen. Fil. 243. 1850–52.
Moist rich woods. Silver Creek. August. No. 915.

Phegopteris phegopteris (L.) UNDERWOOD. Small in Bull. Torr. Bot. Club. **20**:462. 1893.

Woods. Two Harbors. August. No. 895.

Dryopteris fragrans (L.) SCHOTT. Gen. Fil. 1834.
Rocks. Two Harbors. July. No. 461.

Dryopteris spinulosa (RETZ.) KUNTZE. Rev. Gen. 813. 1891.
Rich woods. Silver Creek. August. No. 917.

Onoclea sensibilis L. Sp. Pl. 1062. 1753.
Rich woods. Thompson. July. No. 431.

Onoclea struthiopteris (L.) HOFFMANN. Deutsch. Fl. **2**:11. 1795.
Creek bottoms in woods. Thompson. July. No. 418.

Woodsia ilvensis (L.) R. BR. Trans. Linn. Soc. **11**:173. 1812–15.
In crevices of rocks. St. Croix Falls. July. (*J. M. H. coll.*)

Osmunda cinnamonea L. Sp. Pl. 1066. 1753.
Wet woods. Pokegama lake. June. No. 210.

Osmunda claytoniana L. Sp. Pl. 1066. 1753.
Damp woods. Lake Itasca. July. No. 1177.

Osmunda regalis L. Sp. Pl. 1065. 1753.
Low ground. Minneapolis. June. No. 321.

CONIFERAE.

Taxus minor (MICHX.) BRITTON. Mem. Torr. Bot. Club. **5**:19. 1893–94.
Deep ravines. Thompson. June. No. 191.

Juniperus communis L. Sp. Pl. 1040. 1753.
Lake Itasca. June. No. 1099.

Juniperus virginiana L. Sp. Pl. 1039. 1753.
Shores of Lake Itasca. July. No. 1195.

Thuya occidentalis L. Sp. Pl. 1002. 1753.
Lake Pokegama islands. June. No. 242.

Picea mariana (MILL.) B. S. P. Prel. Cat. N. Y. 71. 1888.
Woods. Two Harbors. July. Nos. 462, 463.

Abies balsamea (L.) MILL. Gard. Dict. ed. 8. No. 3. 1768.
Borders of swamps. Lake Itasca. July. No. 1216.

Pinus divaricata (AIT.) SUDW. Bull. Torr. Bot. Club. **20**:44. 1893.
Barren sand, gaining ground. Lake Itasca. July. No. 1214.

Pinus resinosa AIT. Hort. Kew. **3**:367. 1789.
Ridges. Lake Itasca. July. No. 1213.

Pinus strobus L. Sp. Pl. 1000. 1753.
Less plenty than P. divaricata. June. No. 1215.

TYPHACEAE.

Typha angustifolia L. Sp. Pl. 971. 1753.
Wet places. Thompson. July. No. 553.

Typha latifolia L. Sp. Pl. 971. 1753.
Shallow water. Lake Itasca. July. No. 1217.

SPARGANIACEAE.

Sparganium androcladum (ENGELM.) MORONG. Bull. Torr. Bot. Club. **15**:78. 1888.

Wet places. July. No. 654.

Sparganium eurycarpum ENGELM. in A. Gray Man. Ed. 2. 430. 1856.

Wet places. Itasca county. August. No. 757.

Sparganium simplex HUDSON. Fl. Angl. Ed. 2. 401. 1788.
Wet places. Lake Itasca. No. 1182.

NAIADACEAE.

Potamogeton amplifolius TUCKERM. Am. Jour. Sci. (II.) **6**: 225. 1848.

In water. Center City. July. No. 666.

Potamogeton fluitans ROTH. Fl. Germ. 1. 72. 1758.
In water. Itasca and Aitkin counties. Aug. Nos. 744, 814.

Potamogeton pectinatus L. Sp. Pl. 127. 1753.
Shallow water. Minnetonka; Lake Itasca. July. Nos. 637, 1189.

Potamogeton perfoliatus L. Sp. Pl. 126. 1753.
Ponds. Minnetonka; Sandy lake. July, August. Nos. 636, 801.

Potamogeton pusillus L. Sp. Pl. 127. 1753.
Shallow ponds. Thompson; Sandy lake. July. August. Nos. 562, 800.

Potamogeton robbinsii OAKES. Hovey's Mag. **7**:180. 1841.
Ponds. Center City. July. No. 652.

Potamogeton zosteraefolius SCHUMACHER. Enum. Saell. 50, 168. 1801.

Ponds. Minnetonka. July. No. 638.

Naias flexilis WILLD. Rostk. and Schmidt. Fl. Sed. 384. 1824.

In water. Minnetonka. July. No. 639, in part.

JUNCAGINACEAE.

Triglochin maritima L. Sp. Pl. 339. 1753.
Spruce bogs. Partridge river; Lake Itasca. July. Nos. 519, 1203.

Scheuchzeria palustris L. Sp. Pl. 338. 1753.
Bogs. Partridge river. July. No. 520.

ALISMACEAE.

Alisma plantago-aquatica L. Sp. Pl. 342. 1753.
Shallow water, ditches. Vermilion; Minnetonka. July. Nos. 511, 629.

Sagittaria graminea Michx. Fl. Bor. Am. **2**:190. 1803.
Wet places. Minnetonka. July. No. 623.

Sagittaria rigida Pursh. Fl. Am. Sept. 397. 1814.
Wet places. Minnetonka. July. Nos. 624, 633.

Sagittaria latifolia Willd. Sp. Pl. **4**:409. 1806.
Shallow water. Vermilion Lake; Minnetonka; Lake Itasca. July. Nos. 483, 622, 1179.

HYDROCHARITACEAE.

Udora canadensis (Michx.) Nutt. Gen. **2**:242. 1818.
In water. Thompson. July. No. 563.

Vallisneria spiralis L. Sp. Pl. 1015. 1753.
Ponds. Sandy lake. August. No. 803.

GRAMINEAE.

Andropogon nutans var. **avenaceus** (Michx.) Hack. D. C. Monog. Phan. **6**:530. 1889.
Sandy hillsides. Crow Wing county. August. No. 862.

Andropogon provincialis Lam. Ency. Meth. **1**:376. 1783.
Sandy soil. Itasca county. August. No. 757.

Andropogon scoparius Michx. Fl. Bor. Am. **1**:57. 1803.
Sandy soil. Crow Wing county. August No. 857.

Panicum capillare L. Sp. Pl. 58. 1753.
Sandy field. Minneapolis. June. No. 303.

Panicum depauperatum Muhl. Gram. 112. 1817.
Ridges. Lake Itasca. June. No. 1110.

Panicum dichotomum L. Sp. Pl. 58. 1753.
Sandy river banks and dry pine woods. Thompson; Center City; Lake Itasca. June, July. Nos. 385, 666, 1016.

Panicum dichotomum L. var. **elatum** Vasey. Mon. 30. 1892.
Sandy soil. Minneapolis. June. No. 316 in part.

Panicum dichotomum L. var. **villosum** (Ell.) Vasey. Mon. 30. 1892.
Sandy soil. Minneapolis. June. No. 316 in part.

Panicum nitidum LAM. Ency. Meth. **4**:748. 1797.
Dry soil. Lake Itasca. June. No. 1078.

Panicum scoparium LAM. Ency. Meth. **4**:744. 1797.
Sandy soil. Minneapolis. June. No. 270.

Panicum virgatum L. Sp. Pl. 59. 1753.
Shores of Sandy lake. August. No. 766.

Panicum xanthophysum A. GRAY. Ann. Lyc. N. Y. **3**; 233. 1835.
Dry sandy soil. Lake Itasca, Park Rapids. June, July. Nos. 1019, 1128, 1236.

Chamaeraphis glauca (L.) KUNTZE. Rev. Gen. 767. 1891.
Sandy soil. Sandy lake. August. No. 810.

Cenchrus tribuloides L. Sp. Pl. 1050. 1753.
Sandy soil. Brainerd. August. No. 863.

Homalocenchrus oryzoides (L.) POLL. Hist. Pl. Palat. **1**:52. 1776.
Wet places. Minnehaha falls. September. No. 940.

Phalaris arundinacea L. Sp. Pl. 55. 1753.
Shores and shallows. Vermilion lake; Lake Itasca. July. Nos. 481, 1219.

Aristida basiramea ENGELM. in Vasey. Bot. Gaz. **9**:76. 1884.
Moist places. Gull river. August. No. 890.

Stipa spartea TRIN. Mem. Acad. St. Petersb. (VI.) **1**:82. 1831.
Sandy hills. Minneapolis. June. No. 299.

Oryzopis asperifolia MICHX. Fl. Bor. Am. **1**:51. 1803.
Thompson. May. No. 71.

Oryzopsis juncea (MICHX.) B. S. P. Prel. Cat. N. Y. 67. 1888.
On slate rocks. N. P. Junction; Lake Itasca. May, June. Nos. 98, 1017.

Muhlenbergia racemosa (MICHX.) B. S. P. Prel. Cat. N. Y. 67. 1888.
Sandy shores. Minneapolis; Sandy lake. July, August. Nos. 569, 783.

Muhlenbergia mexicana (L.) TRIN. Unifl. 189. 1824.
Low grounds. Minneapolis. September. No. 990.

Brachyelytrum erectum (SCHREB.) BEAUV. Agrost. 39. 1812.
Woods. Aitkin county. August. No. 838.

Phleum pratense L. Sp. Pl. 59. 1753.
Waste places and along trails. Vermilion; Lake Itasca. June, July. Nos. 492, 1114.

Alopecurus geniculatus L. var. **fulvus** (J. E. SMITH.) SCRIBN. Mem. Torr. Bot. Club. 5:38. 1893–94.
Moist places. Thompson. June. No. 193.

Sporobolus brevifolius (NUTT.) SCRIBN. Mem. Torr. Bot. Club. 5:39. 1893–94.
Sandy hillsides. Minnehaha falls. September. No. 947.

Sporobolus cryptandrus (TORR.) A. GRAY. Man. 576. 1848.
Sandy soil. Minneapolis. July. No. 588.

Sporobolus heterolepis A. GRAY. Man. 576. 1848.
Sterile hills. Minneapolis. July. No. 593.

Cinna latifolia (TREV.) GRISEB. Ledeb. Fl. Ross. 4:435. 1853.
Copses and woods. Grand Rapids; Silver creek. August Nos. 713, 902.

Agrostis perennans (WALT.) TUCK. Am. Jour. Sci. 45:44. 1843.
Moist places. Sandy lake. August. No. 782.

Agrostis hiemalis (WALT.) B. S. P. Prel. Cat. N. Y. 68. 1888.
Rocky soil. Minneapolis; Two Harbors; shores of DeSoto lake; Lake Itasca. June, July. Nos. 285, 444, 1111, 1201.

Calamagrostis canadensis (MICHX.) BEAUV. Agrost. 15. 1812.
Copses and shores. Minneapolis; Vermilion; Partridge river; Silver creek; Lake Itasca. June, July, August. Nos. 297, 503, 523, 568, 903, 918, 1205.

Calamagrostis confinis (WILLD.) NUTT. Gen. 1:1818.
Sandy banks. Aitkin county; shores of DeSoto lake. June, August. Nos. 815, 1115.

Calamovilfa longifolia (HOOK.) HACK. True grasses. 113. 1890.
Copses. Minneapolis. July. No. 580.

Deschampsia caespitosa (L.) BEAUV. Agrost. 160. 1812.
Crevices of rocks. Thompson; Two Harbors. July. Nos. 394, 395, 533.

Trisetum subspicatum BEAUV. var. **molle** (MICHX.) A. GRAY. Man. Ed. 2. 572. 1856.
Crevices of rocks. Two Harbors. July. No. 443.

Avena striata MICHX. Fl. Bor. Am. 1:73. 1803.
Slate rocks. N. P. Junction; Lake Itasca. May, June. Nos. 101, 1026.

Danthonia spicata (L.) BEAUV. R. & S. Syst. 2: 690. 1817.
Woods. Lake Itasca. June. No. 1117.

Spartina cynosuroides (L.) WILLD. Enum. 80. 1809.
Wet places. Center City. July. No. 671.

Bouteloua hirsuta LAG. Var. Cienc y Litt. 2: Pt. 4. 141. 1805.
Sandy plains. Minneapolis. July. No. 577.

Bouteloua hirsuta (MICHX.) TORR. Emory Rep. 153. 1848.
Sterile hills. Minneapolis. July. No. 594.

Phragmites phragmites (L.) KARST. Deutsch. Fl. 379. 1880-83.
Wet shores. Center City. No. 940.

Eragrostis pectinacea (MICHX.) STEUD. Syn. Pl. Gram. 272. 1855.
Sandy soil. Minneapolis. July. No. 570.

Eragrostis major HOST. Gram. Austr. 4:14. *t. 24.* 1809.
Sandy soil. Brainerd. August. No. 864.

Eragrostis hypnoides (LAM.) B. S. P. Prel. Cat. N. Y. 69. 1888.
River banks. Aitkin county. August. No. 846.

Koeleria cristata (L.) PERS. Syn. 1: 97. 1805.
Sandy soil. Minneapolis. June. No. 313.

Eatonia pennsylvanica (D. C.) A. GRAY. Man. Ed. 2. 558. 1856.
Wet places. Aitkin county. August. No. 818.

Poa compressa L. Sp. Pl. 69. 1753.
Meadows and in sandy soil. Minneapolis. June, July. Nos. 264, 607.

Poa debilis TORR. Fl. N. Y. 2:459. 1753.
Woodland swamps. Itasca lake. June. No. 1069.

Poa nemoralis L. Sp. Pl. 69. 1753.
Rocks. Thompson; Lake Itasca. July. Nos. 406, 1254.

Poa nemoralis L. var. **firmula** Host. Gram. Aust. 2: *t. 71.* 1804.
Rocks. Two Harbors. July. No. 439.

Poa alsodes A. Gray. Man. Ed. 2. 562. 1856.
Low grounds. Silver creek. June. No. 178.

Poa pratensis L. Sp. Pl. 67. 1753.
Railway tracks, sandy soil and meadows. N. P. Junction; Thompson; Lake Pokegama islands; Lake Itasca. June, July. Nos. 168, 194, 244, 1139.

Poa flava L. Sp. Pl. 68. 1753.
R. R. tracks, shores, swamps. Thompson; Minnetonka lake; lake Itasca. July. Nos. 402, 630. 1210.

Panicularia nervata (Willd.) Kuntze. Rev. Gen. 783. 1891.
Meadows and streams. Two Harbors; lake Itasca. July. Nos. 453, 1142, 1229, 1251.

Panicularia aquatica (L.) Kuntze. Rev. Gen. 782. 1891.
Streams. Wadena county. July. No. 1228.

Panicularia fluitans (L.) Kuntze. Rev. Gen. 782. 1891.
Wet places. Thompson. July. No. 387.

Panicularia canadensis (Michx.) Kuntze. Rev. Gen. 783. 1891.
Wet places. N. P. Junction. August. No. 920.

Panicularia americana (Torr.) Macm. Met. Minn. Vall. 81. 1892.
Wet places. Thompson. July. No. 388.

Festuca nutans Willd. Enum. **1**:116. 1809.
Wet woods. Minneapolis; Itasca county. June, August. Nos. 274, 280, 998.

Festuca ovina L. Sp. Pl. 73. 1753.
Rocks. Two Harbors. July. No. 445.

Festuca octoflora Walt. Fl. Car. 81. 1788.
Sandy soil. Cannon Falls. June. No. 338.

Bromus ciliatus L. Sp. Pl. 76. 1753.
Copses and woods. Aitkin county; Silver creek. August. Nos. 819, 905.

Bromus ciliatus L. var. **purgans** (L.) A. Gray. Man. 567. 1856.
Copses. Cannon Falls. June. No. 330.

Bromus kalmii A. Gray. Man. 600. 1848.
River banks. Aitkin county. No. 812.

Bromus racemosus L. Sp. Pl. ed. II. 114. 1762.
Copses. Cannon Falls. June. 327.

Agropyron caninum (L.) ROEM & SCHULT.
var. **unilaterale** VASEY. Rocks. Thompson. July. No. 407.

Agropyron repens (L.) BEAUV var. **glaucum** (DESF.) SCRIB. Mem. Torr. Bot. Club. **5**: 57. 1893–94.
Rich woods. Minneapolis. June. No. 294.

Agropyron repens (L.) BEAUV. Agrost. 146. 1812.
Sandy soil. Minneapolis; Cannon Falls; lake Itasca. June, July. Nos. 282, 340, 1141.

Agropyron repens (L.) BEAUV. forma **aristulata.** VASEY.
Waste places. July. No. 493.

Hordeum jubatum L. Sp. Pl. 85. 1753.
Sandy soil. Thompson. July. No. 420.

Elymus canadensis L. Sp. Pl. 83. 1753.
Sandy soil. Minneapolis; Sandy lake. July, August. Nos. 567, 770.

Elymus virginicus L. Sp. Pl. 84. 1753.
Shores and copses. Sandy lake; Grand Rapids. August. Nos. 714, 771.

Hystrix hystrix (L.) MILLSPAUGH Fl. W. Va. 474. 1892.
Copses. Minnetonka lake. July. No. 617.

CYPERACEAE.

Cyperus aristatus ROTTB. Descr. et. I. con. *23. t. 6. f. 1.* 1773.
Shores. Sandy lake. August. No. 768.

Cyperus diandrus TORR. Cat. Pl. N. Y. 90. 1819.
Shores. Morrison county. August. No. 882.

Cyperus engelmannii STEUD. Syn. Pl. Cyp. 47. 1855.
Shores. Centre City; Ramsey county. July, September Nos. 651, 931.

Cyperus filiculmis VAHL. Enum. **2**: 328. 1806.
Sandy soil. Minneapolis. July. No. 564.

Cyperus schweinitzii TORR. Ann. Lyc. N. Y. **3**: 276. 1836.
Copses. Minneapolis. July. No. 587.

Dulichium arundinaceum (L.) BRITT. Bull. Torr. Bot. Club. **21**: 29. 1894.
Wet places. Centre City. July. No. 644.

Eleocharis acicularis (L.) R. & S. Syst. **2**: 154. 1817.
Wet sandy shores. Aitkin county. August. No. 816.

Eleocharis ovata (ROTH) R. & S. Syst. :2 152. 1817.
Wet places. Centre City. July. No. 669.

Eleocharis palustris (L.) R & S. Syst. 2: 151. 1817.
Shallows. Lake Itasca. June. No. 1112.

Scirpus atrovirens MUHL. Gram. 43. 1817.
Bogs. Thompson. Itasca county. July, August. Nos. 558, 750.

Scirpus caespitosus L. Sp. Pl. 48. 1753.
Wet rocks. Two Harbors. July. No. 460.

Scirpus debilis PURSH. Fl. Am. Sept. 55. 1814.
Wet places. Minnetonka; Centre City. July. Nos. 627, 670.

Scirpus fluviatilis (TORR.) A. GRAY. Man. 527. 1848.
In water. Vermilion lake. July. Nos. 497, 498.

Scirpus lacustris L. Sp. Pl. 48. 1753.
Shallows. Lakes Vermilion and Itasca. July. Nos. 499, 1224.

Scirpus torreyi OLNEY. Proc. Prov. Frankl. Soc. 1: 32. 1847.
Wet places. Minnetonka. July. No. 628.

Scirpus cyperinus (L.) KUNTH. Enum. 2: 170. 1837.

Eriophorum alpinum L. Sp. Pl. 53. 1753.
Bogs. Partridge river. July. No. 524.
Swales. Vermilion; Thompson; Lake Itasca. July. Nos. 505, 557, 1209.

Eriophorum gracile KOCH. Rost. Cat. 2: 259. 1800.
Swamps. Partridge river; Chisago City; lake Itasca. July. Nos. 529, 695, 1126.

Eriophorum polystachyon L. Sp. Pl. 52. 1753.
Swamps. Minneapolis. June. No. 310.

Eriophorum virginicum L. Sp. Pl. 53. 1753.
Bogs. Chisago City. July. Nos. 682, 692.

Rhynchospora alba (L.) VAHL. Enum. 2: 236. 1806.
Bogs. Chisago City. July. No. 691.

Carex arctata BOOTT. Hook. Fl. Bor Am. 2: 227. 1840.
Rich woods. Silver creek. June. Nos. 177, 181.

Carex aurea NUTT. Gen. 2: 205. 1818.
Meadows. Lake Itasca. July. No. 1137.

Carex canescens L. Sp. Pl. 974. 1753.

Low grounds and rocks. Thompson; Sugar brook; Two Harbors; lake Itasca. June, July. Nos. 152, 222, 455, 1161, 1169.

Carex canescens L. var. **brunnescens** (PERS.) POIR. Lam. Ency. Meth. Suppl. **3**: 286. 1813.

On slates, rocks, and swamps. Thompson; N. P. Junction. June. Nos. 154, 169.

Carex capillaris L. Sp. Pl. 977. 1753.

Lake Itasca. July. No. 1140.

Carex castanea WAHL. Kongl. Vet. Acad. Handl. **24**: 155. 1803.

Woods. Thompson. June. No. 149.

Carex cephaloidea DEWEY. Rep. Pl. Mass. 262. 1840.

Sterile hills. Minneapolis. June. No. 258.

Carex crinita LAM. Ency. Meth. **3**: 393. 1789.

Wet places. Thompson. July. No. 432.

Carex debilis MICHX. var. **pubera.** A. GRAY. Man. ed. 5. 593. 1867.

Rich woods. Silver creek. June. No. 183.

Carex deweyana SCHWEIN. Ann. Lyc. N. Y. **1**: 65. 1824.

Shady woods. Thompson; lake Itasca. June, July. Nos. 140, 1152.

Carex sartwellii DEWEY. Am. Jour. Sci. **43**: 90. 1842.

Meadows. Lake Itasca. July. No. 1138.

Carex sterilis WILLD. Sp. Pl. **4**: 208. 1805.

Swamps, peat bogs. Minneapolis; lake Itasca. June. Nos. 324, 1079.

Carex filiformis L. Sp. Pl. 976. 1753.

Lake Itasca. June. No. 1118.

Carex flava L. Sp. Pl. 975. 1753.

Shores. Morrison county August. No. 884.

Carex flava L. var. **viridula** (MICHX.) BAILEY. Mem. Torr. Bot. Club. **1**: 31. 1889.

Swamps. Lake Itasca. July. No. 1127.

Carex foenea WILLD. var. **perplexa** BAILEY. Mem. Torr. Bot. Club. **1**: 27. 1889.

Slate rock. Sterile hills, N. P. Junction. Minneapolis. June. Nos. 250, 273.

Carex fusca ALL. Fl. Ped. **2**: 269. 1785.
Wet places, on rocks. Two Harbors. July. No. 452.

Carex gracillima SCHW. Ann. Lyc. N. Y. **1**: 66 1824.
Along water courses. Lake Itasca. June. No. 1057.

Carex redowskyana C. A. MEYER. Mem. Ac. St. Pet. Div. Sav. **1**: 207. *t. 4.* 1825–31.
Lake Itasca. July. No. 1124.

Carex houghtonii TORR. Ann. Lyc. N. Y. **3**: 413. 1836.
Along railways, moist pine ridges. Two Harbors; lake Itasca. May, June. Nos. 107, 1055.

Carex hystricina MUHL. in Willd. Sp. Pl. **4**: 282. 1805.
Moist sandy shores. Sugar brook; lake Itasca. June. Nos. 226, 1113.

Carex intumescens RUDGE. Trans. Linn. Soc. **7**: 97. *t. 9. f. 3.* 1804.
Wet places. Thompson. June. No. 188.

Carex lenticularis MICHX. Fl. Bor. Am. **2**: 172. 1803.
Rocks. Two Harbors. July. No. 458.

Carex longirostris TORR. Schwein. Ann. Lyc. N. Y. **1**: 71. 1824.
Rich woods. Silver creek. June. No. 182.

Carex magellanica LAM. Ency. Meth. **3**: 385. 1789.
Bogs, Minneapolis. Lake Itasca. June. Nos. 322. 1040.

Carex monile TUCK. Enum. Meth. 20. 1843.
Moist places. Thompson. June. No. 189.

Carex novae-angliae SCHWEIN. Ann. Lyc. N. Y. **1**: 68. 1824,
Lake Pokegama islands. June. No. 243.

Carex oligosperma MICHX. Fl. Bor. Am. **2**: 174. 1803.
Bogs. Sandy Lake. August. No. 809.

Carex pedunculata MUHL. Willd. Sp. Pl. **4**: 222. 1805.
Deep woods. Two Harbors. May. No. 111.

Carex pennsylvanica LAM. Ency. Meth. **3**: 388. 1789.
Woods and sterile hills. Thompson; Minneapolis; lake Itasca. May, June. Nos. 83, 257, 1018.

Carex leptalea WAHL. Kongl. Vet. Ac. Handl. (II.) **24**: 139. 1803.
Bogs. Partridge river. Lake Itasca. June, July. Nos. 525, 1049.

Carex retrorsa SCHW. Ann. Lyc. N. Y. **1**:71. 1824.
Wet places. Cannon Falls. June. No. 333.

Carex riparia CURTIS. Fl. Lond. **4**: *t. 60.* 1821.
Wet places. Sugar brook; lake Itasca. June. Nos. 224. 1168.

Carex lurida WAHL. Kongl. Vet. Ac. Handl. (II.) **24**:153. 1803.
Shallows. Lake Itasca. July. No. 1180.

Carex scoparia SCHKUHR. Riedgr. Nachtr. 20. *f. 175.* 1806.
Minneapolis. June. No. 314.

Carex stipata MUHL. Willd. Sp. Pl. **4**: 233. 1805.
Moist places. Sugar brook. June. No. 225.

Carex straminea WILLD. var. **festucacea** (WILLD.) TUCKM. Enum. Meth. 18. 1843.
Sandy soil. Cannon Falls. June. No. 337.

Carex stricta LAM. Ency. Meth. **3**: 387. 1789.
Meadows. Lake Itasca. July. No. 1135.

Carex stricta LAM. var. **decora** Bailey. Bot. Gaz. **13**: 85. 85. 1888.
Marshes. Minneapolis. June. No. 320.

Carex sychnocephala CAREY. Am. Jour. Sci. (II.) **4**: 24. 1847.
Wet places. Morrison county. August. No. 876.

Carex tenella SCHKUHR. Riedgr. 23, *f. 104.* 1801.
Swamps. Thompson; lake Itasca. June, July. Nos. 295, 1125, 1136.

Carex teretiuscula GOOD. Trans. Linn. Soc. **2**: 163. *t. 19.* 1794.
Swamps. Sugar brook; lake Itasca. June, July. Nos. 221, 1122.

Carex abbreviata PRESCOTT. Boott. Linn. Trans. **20**: 141. 1846.
Minneapolis. May. No. 116.

Carex tribuloides WAHL. Kongl. Ac. Handl. (II.) **24**: 145. 1803.
Sterile hills and meadows. Minneapolis, lake Itasca. June, July. Nos. 275, 314, 1134.

Carex tribuloides WAHL. var. **reducta** BAILEY Proc. Am. Acad. **22**: 118. 1886.
Sloughs. Lake Itasca. July. No. 1164.

Carex trisperma Dewey. Am. Jour. Sci. 9:63. 1825.
Meadows. Vermilion. July. No. 501.

Carex umbellata Schkuhr. Riedgr. Nachtr. 75. *f. 171.* 1806.
Crevices of rocks. Thompson; lake Itasca. May, June. Nos. 69, 1109.

Carex utriculata Boott. Hook. Fl. Bot. Am. 2:221. 1840.
Sloughs. Sugar brook; lake Itasca. July. Nos. 224, 1168.

Carex varia Muhl. Wahl. Kongl. Acad. Handl. (II). **24**:159. 1803.
Slate rocks. N. P. Junction; Thompson. May, June. Nos. 100, 296.

Carex vulpinoidea Michx. Fl. Bor. Am. 2:169. 1803.
Wet places. Cannon Falls. June. No. 334.

ARACEAE.

Acorus calamus L. Sp. Pl. 324. 1753.
Shallow water. Centre City; lake Itasca. July. Nos. 653, 1231.

Calla palustris L. Sp. Pl. 968. 1753.
Marshes, in woods. N. P. Junction. June. No. 166.

Arisaema triphyllum (L.) Torr. Fl. N. Y. 2: 239. 1843.
Rich moist woods. Thompson. June. No. 142.

ERIOCAULACEAE.

Eriocaulon septangulare Withering. Bot. Arr. Brit. Pl. 784. 1776.
Muddy shores. Morrison county. August. No. 887.

COMMELINACEAE.

Tradescantia virginiana L. Sp. Pl. 288. 1753.
Sandy exposed soil. Minneapolis. June. No. 291.

PONTEDERIACEAE.

Pontederia cordata L. Sp. Pl. 288. 1753.
In water. Ramsey county. September. No. 930.

JUNCACEAE.

Juncus alpinus Villars, var. **insignis** Fries, Engelm. Trans St. Louis Acad. 2:459. 1868.
Wet rocks. Two Harbors. July. No. 456.

Juncus balticus DETHARD, var. **littoralis** ENGELM. Trans. St. Louis Acad. 2: 442. 1866.
Sandy shores. Chisago City. July. No. 675.

Juncus canadensis J. GAY. De Laharpe Mem. Soc. Hist. Nat. Paris. 3: 134. 1827.
Bogs. Chisago City. July. No. 681.

Juncus effusus L. Sp. Pl. 326. 1753.
Wet places. Vermilion lake. July. No. 610.

Juncus filiformis L. Sp. Pl. 326. 1753.
Wet places. Thompson. July. No. 409.

Juncus nodosus L. Sp. Pl. ed. 2. 466. 1762.
Sandy shores. Hubbard county. July. No. 1247.

Juncus pelocarpus E. H. MEYER. Syn. Luz. 30. 1823.
Sandy shores. Centre City. July. No. 650.

Juncus tenuis WILLD. Sp. Pl. 2: 214. 1799.
Wet shores. Thompson; De Soto. June, July. Nos. 554, 1107.

Juncodes campestre (L.) KUNTZE. Rev. Gen. Pl. 2: 722. 1891.
Low grounds. Minneapolis; De Soto. June. Nos. 383, 1116.

Juncodes spicatum (L.) KUNTZE. Rev. Gen. Pl. 725. 1891.
Wet places. Minneapolis. June. No. 325.

Juncodes pilosum (L.) KUNTZE. Rev. Gen. Pl. 725. 1891.
Grassy banks and wet meadows. Thompson; Lake Itasca. Nos. 63, 1,072.

LILIACEAE.

Tofieldia palustris HUDSON. Fl. Angl. ed. 2. 157. 1788.
Wet rocky places. Two Harbors. July. No. 437.

Zygadenus elegans PURSH. Fl. Am. Sept. 241. 1814.
Stony hills. Cannon Falls. July (fruit). Nos. 348, 372.

Uvularia sessilifolia L. Sp. Pl. 305. 1753.
Rich woods. Thompson; Aitkin county. May, August (fruit). Nos. 86, 827.

Uvularia grandiflora J. E. SMITH. Ex. Bot. 1: 99 *t. 51.* 1804–5.
Woods. Lake Itasca. June. No. 1082.

Uvularia perfoliata L. Sp. Pl. 304. 1753.
Rich copses and woods. Fort Snelling; Pokegama lake. May, June (fruit). Nos. 38, 216.

Allium stellatum KER. sub. nom. Gawler. Bot. Mag. *t. 1576.* 1813.

Hill sides. Morrison county. August. No. 879.

Allium tricoccum AIT. :428. 1789.

Rich woods. Thompson; Cannon Falls. May (leaves), July (fruit). Nos. 89, 356.

Lilium canadense L. Sp. Pl. 303. 1753.

River banks. Thompson. July. No. 550.

Lilium philadelphicum L. Sp. Pl. ed. 2. 435. 1762.

Prairies. Minneapolis. June. No. 304.

Erythronium americanum KER. sub. nom. Gawler. Bot. Mag. *t. 1113.* 1808.

Rich woods. St. Louis river; Thompson. May, June (fruit). Nos. 21, 150.

Erythronium propullans A. GRAY. Am. Nat. 298 *t. 74.* 1871.

Rich woods. Faribault. May. No. 58.

Vagnera racemosa (L.) MORONG. Mem. Torr. Bot. Club. **5**: 114. 1893–94.

Copses and woods. Lakes Pokegama and Itasca. June, July (fruit). Nos. 247, 1163.

Vagnera stellata (L.) MORONG. Mem. Torr. Bot. Club. **5**: 114. 1893–4.

Copses and woods, in sandy soil. Silver creek; Cannon Falls. June, July (fruit). Nos. 175, 352.

Vagnera trifolia (L.) MORONG. Mem. Torr. Bot. Club. **5**: 114. 1893–4.

Bogs. Lake Itasca. June. No. 1050.

Unifolium canadense (DESF.) GREENE. Bull. Torr. Bot. Club. **15**: 287. 1888.

Woods. Thompson; Aitkin county. June, August (fruit). Nos. 143, 835.

Streptopus roseus MICHX. Fl. Bor. Am. **1**: 201. 1803.

Rich woods. Thompson; Pokegama lake; lake Itasca. June, August (fruit). Nos. 145, 205, 829.

Polygonatum biflorum var. **commutatum** (R. & S.) MORONG. Mem. Torr. Bot. Club. **5**: 115. 1893–94.

Copses. Pokegama lake. June. No. 245.

Clintonia borealis (AIT.) RAF. Atl. Jour. 120. 1832.

Rich woods. Thompson; Aitkin county; lake Itasca. June, July and August (fruit). Nos. 144, 561, 828, 1154.

Trillium cernuum L. Sp. Pl. 339. 1753.
Rich low woods. Fort Snelling; Thompson. May. Nos. 46, 79.

Trillium erectum L. Sp. Pl. 340. 1753.
Copses and woods. Crow Wing county; lake Itasca. July, August (fruit). Nos. 1001, 1167.

Trillium grandiflorum (MICHX.) SALISB. Par. Lond. **1**: *t. i.* 1805.
Rich woods. Thompson. May. No. 80.

AMARYLLIDACEAE.

Hypoxis hirsuta (L.) COV. Mem. Torr. Bot. Club. **5**: 118. 1893–4.
Sterile hills. Minneapolis. June. No. 256.

DIOSCOREACEAE.

Dioscorea villosa L. Sp. Pl. 1033, 1753.
Copses. Cannon Falls. July. No. 364.

IRIDACEAE.

Iris versicolor L Sp. Pl. 39. 1753.
Edge of lakes. Pokegama lake; Chisago City; lake Itasca. June, July (fruit). Nos. 208, 680, 1153.

Sisyrinchium bermudiana L. Sp. Pl. 954. 1753.
Dry, sandy soil. Minneapolis. June. No. 308.

ORCHIDACEAE.

Cypripedium acaule AIT. Hort. Kew. **3**: 303. 1789.
Swamps. Lake Itasca. July. No. 1143.

Cypripedium parviflorum SALISB. Linn. Trans. **1**: 77. 1791.
Bogs. Thompson; lake Itasca. June, July. Nos. 148, 1041, 1248.

Cypripedium hirsutum MILL. Gard. Dict. ed. 8. No. 3. 1768.
Woods. Hubbard county. July. No. 1244.

Cypripedium reginae WALT. Fl. Car. 222. 1788.
Bogs. Minneapolis; lake Itasca. June. Nos. 315, 1048.

Orchis rotundifolia PURSH. Fl. Am. Sept. 588. 1814.
Cold bogs. Lake Itasca. June. No. 1014.

Habenaria bracteata (WILLD.) R. BR. in Ait. Hort. Kew. ed. 2. **5**: 192. 1813.
Park Rapids. June. Nos. 1223, 1235.

Habenaria dilatata (PURSH) HOOK. Exot. Fl. **2**: *t. 95.* 1825.
Sphagnum swamps. Partridge river; lake Itasca. July. Nos. 518, 1186.

Habenaria hookeriana A. GRAY. Ann. Lyc. N. Y. **3**: 229. 1836.
Bogs and copses. Aitkin county; lake Itasca. June, August (fruit). Nos. 832, 1102.

Habenaria hyperborea (L.) R. BR. in Ait. Hort. Kew. ed. 2. **5**: 193. 1813.
Bogs and copses. Minneapolis; Thompson; lake Itasca. June, July (fruit). Nos. 323, 549, 1020.

Habenaria obtusata (PURSH) RICHARDSON. App. Frankl. Journ. 750. 1823.
Bogs and rich woods. Two Harbors; Silver creek; lake Itasca. June, July, August (fruit). Nos. 467, 911, 1054.

Habenaria orbiculata (PURSH) TORR. Comp. 318. 1826.
Meadows, Sphagnum swamps and woods. Two Harbors; Centerville; lake Itasca. July. Nos. 466, 710, 1185.

Habenaria psycodes (L.) A. GRAY. Am. Jour. Sci. **38**: 310. 1840.
Wet meadows. Chisago City. July. No. 679.

Habenaria clavellata (MICHX.) SPRENG. Syst. **3**: 689. 1826.
Swamps. Centerville. July. No. 708.

Pogonia ophioglossoides (L.) KER. Lindl. Bot. Reg. *t. 148.* 1816.
Bogs. Minneapolis; Chisago City. June, July (fruit). Nos. 311, 694.

Arethusa bulbosa L. Sp. Pl. 950. 1753.
Bogs. Partridge river. July. No. 517.

Gyrostachys cernua (L.) KUNTZE. Rev. Gen. Pl. 664. 1891.
Borders of swamps. Crow Wing county. August. No. 852.

Gyrostachys gracilis (BIGEL.) KUNTZE. Rev. Gen. Pl. 664. 1891.
Dry woodland. Grand Rapids. August. No. 724.

Listera cordata (L.) R. BR. in Ait. Hort. Kew. ed. 2. **5**: 201. 1813.
Bogs. Lake Itasca. June. No. 1038.

Peramium repens (L.) SALISB. Trans. Hort. Soc. 1. 301. 1812.

Bogs and wet woods. Aitkin county; lake Itasca. July, August. Nos. 831, 1194, 1225.

Achroanthes monophylla (L.) GREENE. Pitton. **2**: 183. 1891.
Woods. Aitkin county. August. No. 830.

Achroanthes unifolia (MICHX.). RAF. Med. Repos. (II.) **5**: 352. 1808.

Sandy pine barrens. Centerville; Hubbard county. July. Nos. 703, 1250.

Leptorchis loeselii (L.) MACM. Met. Minn. Vall. 173. 1892.
Bogs. Minneapolis. September (fruit). No. 1008.

Calypso bulbosa (L.) OAKES. Cat. Verm. Pl. 28. 1842.
Deep ravines, and cold damp woods. Thompson; Two Harbors. May, July (fruit). Nos. 93, 414, 535.

Corallorrhiza corallorhiza (L.) KARST. Deutsch. Fl. 2148. 1880–83.

Moist woods and bogs. Thompson; lake Itasca. May, June. Nos. 94, 1053.

Limodorum tuberosum L. Sp. Pl. 950. 1753.
Bogs and swamps. Minneapolis; Centerville; lake Itasca. June, July (fruit). Nos. 318, 707, 1188.

MYRICACEAE.

Comptonia peregrina (L.) COULTER. Mem. Torr. Bot. Club. **5**: 127. 1893–4.

Sandy woods. N. P. Junction; Grand Rapids. June, August (fruit). Nos. 159, 730.

Myrica gale L. Sp. Pl. 1024, 1753.
Cold wet woods. Head of St. Louis River; Two Harbors. May, July (fruit). Nos. 105, 530.

SALICACEAE.

Salix lucida MUHL. Neue. Sch. Ges. Nat. Fr. Berl. **4**: 239. *t. 6. f. 7.* 1803.

Low ground. Thompson. May, June (leaves). Nos. 61, 151.

Salix myrtilloides L. Sp. Pl. 1019. 1753.
Bogs. Partridge river. July. No. 521.

Populus grandidentata MICHX. Fl. Bor. Am. **2**: 243. 1803.
Very common. N. P. Junction. May. No. 4.

BETULACEAE.

Corylus americana WALT. Fl. Car. 236. 1788.
Copses. Centre City; lake Itasca. June, July (fruit). Nos. 642, 1059.

Corylus rostrata AIT. Hort. Kew. 3:364. 1789.
Copses. The prevailing species around lake Itasca. Also at Vermilion lake. June, July (fruit). Nos. 512, 1028.

Betula glandulosa MICHX. Fl. Bor. Am. 2:180. 1803.
Bogs. Partridge river. July. No. 522.

Betula lenta L. Sp. Pl. 983. 1753.
Woods. Thompson. June. No. 186.

Betula nigra L. Sp. Pl. 982. 1753.
Marshy ground. Long lake. May. No. 54.

Betula papyrifera MARSH. Arb. Am. 19. 1785.
Woods. Thompson. May, June (fruit and leaves). Nos. 95, 192.

Betula pumila L. Mant. 124. 1767.
Bogs. Centre City July. No. 648.

Alnus incana (L.) WILLD. Sp. Pl. 4:335. 1805.
Along banks of creeks. Centre City; lake Itasca. July. Nos. 647, 1220.

Alnus rugosa (EHRH.) KOCH. Dendr. 2:635. 1872.
Moist places. Two Harbors. July (fruit). No. 538.

Alnus viridis (CHAIX.) DC. Fl. Fr. 3:304. 1805.
Along water courses. N. P. Junction; Two Harbors; lake Itasca. May. July (fruit). Nos. 67, 447, 1074.

URTICACEAE.

Urtica gracilis AIT. Hort. Kew. 3:341. 1789.
Moist places. Lakes Vermilion and Itasca. July. Nos. 507, 1202.

Adicea pumila (L.) RAF. Torr. Fl. N. Y. 2:223. 1843.
Moist places. Aitkin county. August. No. 839.

Parietaria pennsylvanica MUHL. Willd. Sp. Pl. 4:955. 1805.
Rich shady woods. Minneapolis. May. No. 117.

SANTALACEAE.

Comandra umbellata (L.) NUTT. Gen. 1:157. 1818.
Dry hills. Lake Itasca. June. No. 1062.

ARISTOLOCHIACEAE.

Asarum canadense L. Sp. Pl. 442. 1753.
Rich leaf mould, on shady wooded hillsides. Fort Snelling; lake Itasca. May, June. Nos. 45, 1052.

POLYGONACEAE.

Rumex acetosella L. Sp. Pl. 338. 1753.
Road sides. Vermilion lake. July. No. 488.

Rumex britannica L. Sp. Pl. 334. 1753.
Bogs. Sandy lake.

Rumex persicarioides L. Sp. Pl. 335.
River banks. Aitkin county. August. No. 813.

Polygonum punctatum Ell. Bot. S. C. and Ga. 1:455. 1817.
Moist places. Centre City. July. No. 968.

Polygonum amphibium L. Sp. Pl. 361. 1753.
In water. Centre City. July. No. 657.

Polygonum cilinode Michx. Fl. Bor. Am. 1:241. 1803.
Sandy hillsides. Pokegama lake; lake Itasca. June. Nos. 204, 1015.

Polygonum scandens L. Sp. Pl. 364. 1753.
Sandy soil. Grand Rapids. August. No. 733.

Polygonum hydropiper L. Sp. Pl. 361. 1753.
Wet places. Minneapolis. September. No. 967.

Polygonum incarnatum Ell. Bot. S. C. and Ga. 1:456. 1817.
In wet situations. Minneapolis. September. No. 962.

Polygonum pennsylvanicum L. Sp. Pl. 362. 1753.
In moist situations. Minneapolis. September. No. 961.

Polygonum sagittatum L. Sp. Pl. 363. 1753.
Bogs. Aitkin county. Minneapolis. August. Nos. 833, 992.

CHENOPODIACEAE.

Chenopodium album L. Sp. Pl. 219. 1753.
Moist places. Vermilion lake. July. No. 510.

Chenopodium capitatum (L.) S. Watson. Bot. Cal. 2:48. 1880.
Gravelly soil, and river banks. Lake Pokegama; Aitkin county. August. Nos. 246, 821.

Chenopodium hybridum L. Sp. Pl. 219. 1753.
Waste places. Aitkin county. August. No. 845.

Salsola kali L. var. **tragus** (L.) Moq. in DC. Prodr. **13**: pt. 2. 187. 1849.
Waste places. Gull river. August. No. 889.

AMARANTACEAE.

Acnida tamariscina (Nutt.) Wood. Bot. and Fl. 289. 1873.
Shores. Sandy lake. August. No. 767.

NYCTAGINACEAE.

Allionia hirsuta Pursh. Fl. Am. Sept. 728. 1814.
Sandy soil. Minneapolis. July. No. 584.

Allionia nyctaginea Michx. Fl. Bor. Am. **1**: 100. 1803.
Sandy hillsides. Minnehaha falls. September. No. 945.

AIZOACEAE.

Mollugo verticillata L. Sp. Pl. 89. 1753.
Sandy soil. Chisago City. July. No. 677.

PORTULACACEAE.

Claytonia caroliniana Michx. Fl. Bor. Am. **1**: 160. 1803.
Rich wet soil, in woods. Thompson. May. No. 29.

Claytonia virginica L. Sp. Pl. 204. 1753.
Rich woods. Silver creek. June. No. 174.

CARYOPHYLLACEAE.

Saponaria vaccaria L. Sp. Pl. 409. 1753.
Fields. Aitkin county. August. No. 847.

Silene alba Muhl. Cat. 45. 1813.
Rich woods. Cannon Falls. June. No. 331.

Lychnis githago Scop. Fl. Carn. ed. 2. **1**: 310. 1772.
In fields. Lake Itasca region. July. No. 1211.

Cerastium arvense L. Sp. Pl. 438. 1753.
Prairies. Hubbard county. June. No. 1243.

Cerastium longipedunculatum Muhl. Cat. 46. 1813.
Low rich woods. N. P. Junction, and Minneapolis. June. Nos. 155, 293.

Cerastium vulgatum L. Sp. Pl. ed. 2, 627. 1762.
N. P. Junction. June. No. 172.

Alsine borealis (Bigel.) Britt. Mem. Torr. Bot. Club. **5**: 149. 1893–4.

Cold wet woods, and wet rocks. Two Harbors, Silver creek, and lake Itasca. June to August. Nos. 446, 532, 916, 1035.

Alsine crassifolia (EHRH.) BRITT. Mem. Torr. Bot. Club. 5:150. 1893–4.

Wet places. Pokegama lake, and Itasca county. June, August. Nos. 202, 748.

Alsine longifolia (MUHL.) BRITT. Mem. Torr. Bot. Club. 5:150. 1893–4.

In water. Partridge river. July. No. 527.

Alsine longipes (GOLDIE) COVILLE. Contr. Nat. Herb. 4:70. 1893.

N. P. Junction. June. No. 158.

Arenaria lateriflora L. Sp. Pl. 423. 1753.

Sandy soil. Minneapolis, and Aitkin county. May, August. Nos. 120, 1005.

Arenaria stricta MICHX. Fl. Bor. Am. 1:274. 1803.

Sandy knolls. Cannon Falls. July. No. 370.

NYMPHAEACEAE.

Brasenia purpurea (MICHX.) CASP. Engl. & Prantl. Nat. Pfl. Fam. 3: pt. 2. 6. 1890.

Pond. Center City. July. No. 658.

Nymphaea advena SOLAND. Ait. Hort. Kew. 2:226. 1789.

Ponds and shallows. Minnetonka; Vermilion. July. Nos. 178, 500, 631, 1187.

Castalia odorata (DRYAND.) WOODV. and WOOD. in Rees Cycl. 6: no. 1. 1806.

Ponds. Minnetonka. June, July. Nos. 111, 632, 1124.

RANUNCULACEAE.

Caltha natans PALL. Reise. Russ. 3:284. 1776.

Found floating in ponds, and rooting in mud. It covers an area of two or three acres, in thick masses. Vermilion lake. July. No. 487.

Caltha palustris L. Sp. Pl. 558. 1753.

Wet places. Thompson. Lake Itasca bogs. May, June, July. Nos. 75, 161, 242, 1252.

Isopyrum biternatum (RAF.) TORR. & GRAY. Fl. N. A. 1:660. 1840.

In rich soil. Fort Snelling; Minneapolis. May, June. Nos. 43, 259.

Coptis trifolia (L.) SALISB. Trans. Linn. Soc. **8**: 205. 1803.
Damp woods and bogs. Two Harbors; Thompson. May, June, July. Nos. 30, 84, 539, 1039.

Actæa alba (L.) MILL. Gard. Dict. ed. 8, no. 2. 1768.
Copses. Chisago City; lake Pokegama island. June, July. Nos. 232, 684.

Actæa rubra (AIT.) WILLD. Enum. 561. 1809.
Rich copses and along streams. Center City; Thompson. July. Nos. 140, 141, 659, 1149.

Aquilegia canadensis L. Sp. Pl. 533. 1753.
Copses. Lake Pokegama islands; Thompson. June. Nos. 20, 137, 234, 1029.

Anemone cylindrica A. GRAY. Ann. Lyc. N. Y. **3**: 221. 1836.
Sterile hills. Minneapolis. June, July. Nos. 279, 591, 608.

Anemone quinquefolia L. Sp. Pl. 541. 1753.
Rich woodland and copses. Thompson and N. P. R. R. May, June. Nos. 73, 82, 162.

Anemone canadensis L. Syst. ed. 12. **3**: app. 231. 1768.
Meadows and woods. Silver creek. June, July. Nos. 121, 173, 1130. Fruit; Minneapolis. July, August. Nos. 613, 745.

Anemone virginiana L. Sp. Pl. 540. 1753.
Meadows and copses. Minneapolis. July. Nos. 123, 600, 1132.

Hepatica acuta (PURSH) BRITT. Ann. Acad. N. Y. **6**: 234. 1891.
Woodlands. Silver creek and N. P. R. R. June. Nos. 9, 179.

Syndesmon thalictroides (L.) HOFFMG. Flora **15**: pt. 2. Intell. Beibl. no. 4. 34. 1832.
Minneapolis. May. No. 114.

Pulsatilla hirsutissima (PURSH) BRITT. Ann. Acad. N. Y. **6**: 217. 1891.
Fort Snelling; Prospect Park. May. Nos. 1, 39.

Ranunculus abortivus L. Sp. Pl. 551. 1753.
Moist places. N. P. Junction. May. No. 99.

Ranunculus micranthus NUTT. Torr. and Gray. Fl. N. A. **1**: 18. 1838.
Thompson; St. Louis river. June. No. 122.

Ranunculus acris L. Sp. Pl. 554. 1753.
Low grounds. N. P. Junction. June. No. 251.

Ranunculus reptans L. Sp. Pl. 549. 1753.
From the only sandy place in the Itasca park. Shores of De Soto. June. Nos. 86, 1095, 474.

Ranunculus macounii BRITT. Trans. N. Y. Acad. Sci. **12**: 3. 1892.
Low, wet places. Pokegama lake; Thompson; N. P. Junction. June. Nos. 171, 185, 200.

Ranunculus delphinifolius TORR. in Eaton Man. ed. 2, 395. 1818.
Muddy spots and sloughs. Vermilion. July. Nos. 165, 166, 514, 1175.

Ranunculus purshii RICHARDS. Frank. Journ. 741. 1823.
In stagnant water. Sugar Brook; Cold Springs. June, July. Nos. 136, 220, 1145.

Ranunculus pennsylvanicus L. f. Suppl. 272. 1781.
Wet places; swales. Thompson. July. Nos. 156, 199, 423, 1165, 1208.

Ranunculus recurvatus POIR. Lam. Ency. Meth. **6**: 99. 1804
Low grounds. Minneapolis. May. No. 119.

Ranunculus ovalis RAF. Proc. Dec. 36. 1814.
Dry prairies. Prospect Park. May. No. 3.

Ranunculus sceleratus L. Sp. Pl. 551. 1753.
Brooks. July. Nos. 149, 1158.

Ranunculus septentrionalis POIR. Lam. Ency. Meth. **6**; 125. 1804.
Low grounds. Merriam Park. May. No. 50.

Batrachium divaricatum (SCHRANK.) WIMM. Fl. Schles. 10. 1841.
Ponds. Minnetonka. July. No. 635.

Batrachium trichophyllum (CHAIX.) BOSSCH. Prodr. Fl. Bat. 5. 1850.
Wet places. Lake Vermilion. July. No. 475.

Cyrtorhyncha cymbalaria (PURSH) BRITT. Mem. Torr. Bot. Club. 5: 161. 1893–4.
Wet places. Lake Vermilion. July. No. 504.

Thalictrum dioicum L. Sp. Pl. 545. 1753.

In woods and along streams. Pokegama lake, and Minneapolis. May, June July. Nos. 113, 139, 211, 1148.

Thalictrum polygamum MUHL. Cat. 54. 1813.

Copses and wet places. Itasca county. July, August. Nos. 184, 754, 1193.

Thalictrum purpurascens L. Sp. Pl. 546. 1753.

Woods and meadows. Thompson and Silver creek. July, August. Nos. 390, 391, 907.

BERBERIDACEAE.

Caulophyllum thalictroides (L.) MICHX. Fl. Bor. Am. **1**: 204. 1803.

In rich woodlands. Thompson. May. No. 85.

PAPAVERACEAE.

Sanguinaria canadensis L. Sp. Pl. 505. 1753.

Rich, shady soil. N. P. Junction; Fort Snelling. May. Nos. 6, 47.

Capnodes aureum (WILLD.) KUNTZE. Rev. Gen. Pl. 14. 1891.

Dry, sandy soil. Thompson. Nos. 16, 18, 434, 1025.

Capnodes sempervirens (L.) BORCK. Roem. Arch. **1**: pt. 2. 44. 1797.

In crevices of rocks. N. P. Junction. June. No. 163.

CRUCIFERAE.

Lepidium intermedium A. GRAY. Pl. Wright. **2**: 15. 1853.

Road sides. Minneapolis. June. No. 262.

Thlaspi arvense L. Sp. Pl. 646. 1753.

Probably introduced. N. P. Junction. June. No. 164.

Brassica sinapistrum BOISS. Voy. Espagne. **2**: 36. 1839–45.

Sandy soil. Minneapolis. July. No. 573.

Roripa nasturtium (L.) RUSBY. Mem. Torr. Bot. Club. **3**: no. 3. 5. 1893.

Cold springs. Minnehaha falls. September. Nos. 948, 949.

Roripa palustris (L.) BESS. Enum. 27. 1821.

Sloughs. Minneapolis. July. Nos. 169, 574, 1178.

Cardamine hirsuta L. Sp. Pl. 655. 1753.

Swamps. N. P. Junction. June. No. 170.

Bursa bursa-pastoris (L.) WEBER in Wigg. Prim. Fl. Holst. 41. 1780.

Thompson. June. No. 135.

Descurainia pinnata (WALT.) BRITT. Mem. Torr. Bot. Club. **5**:173. 1893–4.

Sandy places. Sandy lake. August. No. 797.

Arabis brachycarpa (TORR. & GRAY) BRITT. Mem. Torr. Bot. Club. **5**:174. 1893–4.

Sandy soil. Prospect Park; lake Pokegama island. May, June. Nos. 53, 240.

Arabis hirsuta (L.) SCOP. Fl. Carn. ed. 2. **2**:30. 1772.

Dry prairies. Lake Pokegama island. June. Nos. 229, 239, 1239.

Arabis lyrata L. Sp. Pl. 665. 1753.

Sandy banks. Itasca county. August. No. 749.

Arabis glabra (L.) BERNH. Verz. Syst. Erf. 195. 1800.

Dry, sandy soil. Minneapolis. June. Nos. 15, 307, 1024.

Erysimum cheiranthoides L. Sp. Pl. 661. 1753.

River banks. Cannon Falls. July. No. 375.

Erysimum orientale MILL. Gard Dict. ed. 8. no. 4. 1768.

R. R. track. Thompson. July. No. 402 *a*.

Erysimum inconspicuum (S. WATS.) MACM. Met. Minn. Vall. 268. 1892.

Sandy soil. Minneapolis. June. No. 268.

Camelina sativa CRANTZ. Stirp. Austr. ed. 1. Fasc. 1, 14. 1762.

Sandy soil. Minneapolis. June. No. 288.

CAPPARIDACEAE.

Cleome serrulata PURSH. Fl. Am. Sept. 441. 1814.

R. R. tracks. Minneapolis. September. No. 970.

Polanisia graveolens RAF. Am. Jour. Sci. **1**: 378. 1819.

Sandy soil. Minneapolis. September. No. 964.

SARRACENIACEAE.

Sarracenia purpurea L. Sp. Pl. 510. 1753.

Bogs and marshes. Minneapolis. June. Nos. 53, 319, 1044.

DROSERACEAE.

Drosera intermedia HAYNE, in Schrad. Journ. Bot. **1**: 37. 1800.
Bogs. Chisago City. July. No. 689.

Drosera rotundifolia L. Sp. Pl. 281. 1753.
Bogs and wet sandy shores. Chisago City; Morrison county; lake DeSoto. June, July, August. Nos. 690, 886, 1104.

CRASSULACEAE.

Penthorum sedoides L. Sp. Pl. 432. 1753.
Wet ditches. Center City. July. No. 645.

SAXIFRAGACEAE.

Saxifraga pennsylvanica L. Sp. Pl. 339. 1753.
Swamps. N. P. Junction; lake Itasca. June, July. Nos. 156, 1144.

Saxifraga virginiensis MICHX. Fl. Bor. Am. **1**: 269. 1803.
Exposed rocks. Flood bay, near Two Harbors. May. No. 110.

Heuchera hispida PURSH. Fl. Am. Sept. 188. 1814.
Rocky soil. Minneapolis; Thompson. June, July. Nos. 131, 544.

Mitella diphylla L. Sp. Pl. 406. 1753.
Shaded banks. Lake Itasca. July. No. 1146.

Mitella nuda L. Sp. Pl. 406. 1753.
Woods and bogs. Thompson; lake Itasca. June, July. Nos. 147, 413, 1058.

Chrysosplenium americanum SCHWEIN. Hook. Fl. Bor. Am. **1**: 242. 1833.
Cold mountain streams. N. P. Junction. May. No. 96.

Parnassia caroliniana MICHX. Fl. Bor. Am. **1**: 184. 1803.
Moist meadows. Minneapolis. September. No. 957.

Parnassia palustris L. Sp. Pl. 273. 1753.
Springy sandy shores. Waseca county; shores of DeSoto; Hubbard county. June to August. Nos. 747, 1108, 1246.

Ribes cynosbati L. Sp. Pl. 202. 1753.
Copses. Fort Snelling; Minneapolis; Cannon Falls. May, July (fruit). Nos. 40, 115 *b*, 355.

Ribes floridum L'HER. Stirp. Nov. **1**: 4. 1784.
Copses. St. Anthony Park; Itasca county; lake Itasca. May, July, August. Nos. 33, 758, 1190.

Ribes gracile MICHX. Fl. Bor. Am. **1**: 111. 1803.
Copses. St. Anthony Park; Cannon Falls. May, July. Nos. 32, 365.

Ribes lacustre (PERS.) POIR. in Lam. Ency. Meth. Suppl. **2**: 856. 1811.
Rich woods. Silver creek. August. No. 914.

Ribes oxyacanthoides L. Sp. Pl. 201. 1753.
Swamps and copses. Minneapolis; Pokegama lake; Thompson. May to July. Nos. 115, 197, 433.

Ribes prostratum L'HER. Stirp. Nov. **1**: 3. *t. 2.* 1784.
Moist woods. Thompson. May, July (fruit). Nos. 60, 415.

Ribes rubrum L. Sp. Pl. 200. 1753.
Wooded banks of streams. St. Louis river; lake Itasca. May, June. Nos. 20, 1090.

ROSACEAE.

Opulaster opulifolius (L.) KUNTZE. Rev. Gen. Pl. 949. 1891.
River banks. Cannon Falls; Thompson. July. Nos. 380, 392.

Spiraea salicifolia L. Sp. Pl. 489. 1753.
Meadows. Vermilion; Sandy lake; DeSoto. June to August. Nos. 502, 778, 1106.

Spiraea tomentosa L. Sp. Pl. 489. 1753.
Moist meadows. Center City; Minneapolis. July, September. Nos. 644, 988.

Sorbus americana MARSH. Arb. Am. 145. 1785.
Woods. Rare. Lakes Pokegama, Itasca. June. Nos. 199, 1046.

Sorbus sambucifolia (CHAM. & SCHLT.) ROEM. Syn. Mon. **3**: 39. 1847.
Rocks. Two Harbors. July. No. 441.

Amelanchier canadensis (L.) MEDIC. Gesch. 79. 1793.
Copses. Two Harbors; Cannon Falls; lake Itasca. May to July. Nos. 112, 360, 1027.

Crataegus coccinea L. Sp. Pl. 476. 1753.
Copses. Sandy lake. August. No. 779.

Crataegus tomentosa L. Sp. Pl. 476. 1753.
Copses. Sandy lake. August. No. 789.

Rubus canadensis L. Sp. Pl. 494. 1753.
Rocky and sandy soil. Thompson; Centerville. July. Nos. 400, 697.

Rubus parviflorus NUTT. Gen. **1**: 308. 1818.

Copses and woods. Thompson; Two Harbors. July, August. Nos. 416, 893.

Rubus strigosus MICHX. Fl. Bor. Am. **1**: 297. 1803.

Copses. Lakes Pokegama, Vermilion, Itasca. June, July. Nos. 214, 494, 1173.

Rubus americanus (PERS) BRITT. Mem. Torr. Bot. Club. 5: 185. 1893–4.

Low grounds and woods. Thompson. May, July. Nos. 78, 419.

Rubus villosus AIT. Hort. Kew. **2**: 210. 1789.

Copses. Lake Itasca. June. No. 1085.

Fragaria vesca L. Sp. Pl. 494. 1753.

Low ground. Thompson; Sugar brook; lake Itasca. May, June. Nos. 70, 228, 1098.

Fragaria virginiana DUCHESNE, var. **illinoensis** (PRINCE) A. GRAY. Man. ed. 5. 155. 1867.

Rich sandy copses and woods. Thompson; Grand Rapids; lake Itasca. May, June. Nos. 96, 298, 1101.

Potentilla argentea L. Sp. Pl. 497. 1753.

Sandy soil. Minneapolis. July. No. 589.

Potentilla arguta PURSH. Fl. Am. Sept. 736. 1814.

Rocky soil and woods. Thompson; lake Itasca. June, July. Nos. 128, 549, 1067.

Potentilla canadensis L. Sp. Pl. 498. 1753.

Copses. Minneapolis. June. No. 281.

Potentilla fruticosa L. Sp. Pl. 495. 1753.

Copses and crevices of rocks. Two Harbors. July, August. Nos. 440, 900.

Potentilla monspeliensis L. Sp. Pl. 499. 1753.

Roadsides, copses and fields. Lakes Vermilion, Itasca. July. Nos. 490, 1160.

Potentilla pennsylvanica L. Mant. 76. 1767.

Sandy soil. Minneapolis. July. No. 565.

Potentilla millegrana ENGELM. Lehm. Ind. Sem. Hamb. Add. 12. 1849.

Rocky soil. Thompson. July. No. 399.

Potentilla tridentata SOLAND. in Ait. Hort. Kew. **2**: 216. 1789.

Crevices on rocky hills. N. P. Junction; Two Harbors; Hubbard county. June, August. Nos. 252, 899, 1242.

Comarum palustre L. Sp. Pl. 502. 1753.
Wet places and sloughs. Lakes Vermilion and Itasca. June, July. Nos. 480, 1097.

Geum canadense JACQ. Hort. Vindob. **2**: 82. *t. 175.* 1772.
Copses. Minneapolis. July. No. 601.

Geum macrophyllum WILLD. Enum. **1**: 557. 1809.
Meadows. Thompson. July. No. 425.

Geum rivale L. Sp. Pl. 501. 1753.
Low ground along streams. Thompson; lake Itasca. June. Nos. 196, 403, 1013.

Geum strictum AIT. Hort. Kew. **2**: 217. 1789.
Copses. Minneapolis. July. No. 602.

Geum ciliatum PURSH. Fl. Am. Sept. 352. 1814.
Dry prairies and hillsides. Thompson; Minneapolis. May, June. Nos. 30, 260.

Agrimonia striata MICHX. Fl. Bor. Am. **1**: 278. 1803.
Copses and moist places. Vermilion; Chisago City; lake Itasca. July. Nos. 509, 685, 1207.

Rosa arkansana PORTER. Syn. Fl. Colo. 38. 1874.
Sandy soil. Minneapolis. June. No. 305.

Rosa blanda AIT. Hort. Kew. **2**: 202. 1789.
Copses, prairies, river banks, woods. Lake Pokegama; Cannon Falls; Thompson; Sandy lake; lake Itasca. June to August. Nos. 249, 382, 395, 396, 397, 743, 799, 1084.

Rosa humilis MARSH. Arb Am. 136. 1785.
Sterile hills. Thompson; Minneapolis. June, September. Nos. 130, 934.

Rosa lucida EHRH. Beitr. **4**: 22. 1789
Along streams. Lake Pokegama islands; Thompson. June, July. Nos. 238, 543, 546.

Rosa acicularis LINDL. Ros. Monog. 44. *t. 8.* 1820.
Shores. Two Harbors; Sandy lake. July, August. Nos. 449, 798. Sandy lake. August. No. 793. (*R. engelmanni* S. WATS.)

Prunus americana MARSH. Arb. Am. 111. 1785.
Along the Mississippi river. May. No. 35.

Prunus pennsylvanica L. f. Suppl. 252. 1781.
Fort Snelling; Thompson; lake Itasca. May. Nos. 41, 59, 1096.

Prunus pumila L. Mant. 75. 1767.
Sandy shores and prairies. Fort Snelling; N. P. Junction; Sandy lake. May. Fruit in August. Nos. 34, 102, 789.

LEGUMINOSAE.

Baptisia leucantha TORR. & GRAY. Fl. N. Am. **1**: 385. 1840
Copses. Washington county. July. No. 696.

Lupinus perennis L. Sp. Pl. 721. 1753.
Sandy soil. Minneapolis. June. Nos. 300, 312.

Melilotus alba LAM. Ency. Meth. **4**: 63. 1797.
Minnetonka. July. No. 615.

Trifolium hybridum L. Sp. Pl. 766. 1753.
Thompson. June. No. 184.

Trifolium pratense L. Sp. Pl. 768. 1753.
Thompson. July. No. 551.

Psoralea argophylla PURSH. Fl. Am. Sept. 475. 1814.
Sterile hills. Minneapolis. June. No. 278.

Psoralea esculenta PURSH. Fl. Am. Sept. 475. 1814.
Sterile hills. Cannon Falls. June. No. 344.

Amorpha canescens PURSH. Fl. Am. Sept. 467. 1814.
Dry copses. Minneapolis, and Morrison county. July, August. Nos. 581, 875.

Amorpha fruticosa L. Sp. Pl. 713. 1753.
Copses and river banks. Cannon Falls. Nos. 357, 359.

Kuhnistera candida (WILLD.) KUNTZE. Rev. Gen. Pl. 192. 1891.
Copses. Minneapolis. July. No. 578.

Kuhnistera villosa (NUTT.) KUNTZE. Rev. Gen. Pl. 192. 1891.
Sandy hillsides. August. No. 866.

Kuhnistera purpurea (VENT.) MACM. Met. Minn. Vall. 329. 1892.
Copses. Brainerd, and Minneapolis. August, September. Nos. 579, 867, 977.

Astragalus carolinianus L. Sp. Pl. 756. 1753.
Sandy shores. Thompson, and Center City. July. Nos. 548, 672.

Astragalus crassicarpus NUTT. Fras. Cat. 1813.
Sterile gravelly hills. Prospect Park, and Minneapolis. May, June. Nos. 31, 276.

Astragalus neglectus (TORR. & GRAY) SHELD. Minn. Bot. Stud. Bull. 9: 59. 1894.
Sandy shores. Lake Itasca. June. No. 1100.

Glycyrrhiza lepidota PURSH. Fl. Am. Sept. 480. 1814.
Sterile hills and sandy shores. Cannon Falls; Sandy lake; Minneapolis. June to August. Nos. 326, 604, 861.

Meibomia grandiflora (WALT.) KUNTZE. Rev. Gen. Pl. 196. 1891.
Copses. Minnetonka. July. No. 616.

Meibomia canadensis (L.) KUNTZE. Rev. Gen. Pl. 195. 1891.
Copses. Minneapolis. July. No. 575.

Lespedeza capitata MICHX. Fl. Bor. Am. 2: 71. 1803.
Copses, in sandy soil. Minneapolis. August. Nos. 775, 976.

Vicia americana MUHL. Willd. Sp. Pl. 3: 1096. 1803.
Copses. Thompson; lake Itasca. June. Nos. 127, 1081.

Vicia caroliniana WALT. Fl. Car. 182. 1788.
Sandy soil. Thompson. July. No. 252.

Lathyrus maritimus (L.) BIGEL. Fl. Bost. ed. 2. 268. 1824.
Shores. Two Harbors; Silver creek. July, August. Nos. 451, 904.

Lathyrus ochroleucus HOOK. Fl. Bor. Am. 1: 159. 1833.
Copses. Thompson; lake Itasca. June. Nos. 126, 1080.

Lathyrus palustris L. Sp. Pl. 733. 1753.
Low wet meadows. Sugar brook; lake Itasca region. June to August. Nos. 223, 759, 1133.

Lathyrus venosus MUHL. Willd. Sp. Pl. 3: 1092. 1803.
Sandy soil. Lake Pokegama; Centerville; lake Itasca. June, July. Nos. 237, 702, 1131.

Apios apios (L.) MACM. Bull. Torr. Bot. Club. 19: 15. 1892.
Copses. Aitkin county. August. No. 849.

GERANIACEAE.

Geranium carolinianum L. Sp. Pl. 682. 1753.
On rocks. Thompson, and lake Itasca region. June. Nos. 153, 1071.

Geranium maculatum L. Sp. Pl. 681. 1753.
Copses. Thompson, and Minneapolis. June. Nos. 123, 272.

OXALIDACEAE.

Oxalis acetosella L. Sp. Pl. 433. 1753.
Damp cold woods. Two Harbors. July. No. 537.

Oxalis stricta L. Sp. Pl. 435. 1753.
Copses. Cannon Falls. July. No. 381.

LINACEAE.

Linum sulcatum RIDDELL. Suppl. Cat. Ohio Pl. 10. 1836.
Cannon Falls. June. No. 325 *a*.

RUTACEAE.

Xanthoxylum americanum MILL.
Copses. Center City. July. No. 660.

POLYGALACEAE.

Polygala cruciata L. Sp. Pl. 706. 1753.
Meadows. Minneapolis. September. No. 987.

Polygala polygama WALT. Fl. Car. 179. 1788.
Sandy soil. Cannon Falls; Sandy lake. June, August. Nos. 342, 781.

Polygala irridescens L. Sp. Pl. 705. 1753.
Moist places. Centerville. July. No. 704.

Polygala senega L. Sp. Pl. 704. 1753.
Dry hills. Lake Itasca. Sought by Chippewa Indians for its medicinal properties. June. Nos. 263, 1060.

Polygala verticillata L. Sp. Pl. 706. 1753.
Sandy lake. August. No. 784.

EUPHORBIACEAE.

Euphorbia heterophylla L. Sp. Pl. 453. 1753.
Sandy hillsides. Minnehaha falls. September. No. 944.

Euphorbia serpyllifolia PERS. Syn. 2:14. 1807.
Sandy hills. Morrison county; Minnehaha falls. September. Nos. 888, 943

Acalypha virginica L. Sp. Pl. 1003. 1753.
Waste places. Minneapolis. September. No. 953.

ANACARDIACEAE.

Rhus glabra L. Sp. Pl. 265. 1753.
Copses. Cannon Falls; Thompson; N. P. Junction. July. Nos. 349, 401, 921.

No. 401, of which No. 921 is the fruit collected in August, is a peculiar dwarf form. It blooms when only 6 inches high. The leaflets are only 7 to 11, of the texture and shape of Rhus glabra. The fruit is *hispid* as in Rhus typhina. Dr. S. Watson and Dr. John Coulter, to whom specimens of this form were sent, pronounced it a form of Rhus glabra, with the fruit of R. typhina. And both were inclined to consider these two species as one, with this dwarf Minnesota plant as an intermediate form connecting them.

Rhus radicans L. Sp. Pl. 266. 1753.
Sandy soil. Thompson. July. No. 541.

ACERACEAE.

Acer rubrum L. Sp. Pl. 1055. 1753.
Rocky woods. St. Louis river, and N. P. Junction. May, June. Nos. 22, 157.

Acer spicatum Lam. Ency. Meth. **2**: 381. 1786.
Wooded bluffs. Thompson, and lake Itasca region. June, July. Nos. 124, 426, 1218.

BALSAMINACEAE.

Impatiens biflora Walt. Fl. Car. 219. 1788.
Swales. Lake Itasca. July. No. 1232.

Impatiens aurea Muhl. Cat. 261. 1813.
Springy places. Minneapolis. September. No. 960.

RHAMNACEAE.

Ceanothus americanus L. Sp. Pl. 195. 1753.
Copses. Aitkin and Crow Wing counties. August. Nos. 848, 859.

VITACEAE.

Vitis cordifolia Michx. Fl. Bor. Am. **2**: 231. 1803.
Copses. Center City, and Minneapolis. July, September. Nos. 641, 963.

Parthenocissus quinquefolia (L.) PLANCH. DC. Mon. Phan. 5: pt. 2. 448. 1887.

Copses. Sandy lake. August. No. 790.

HYPERICACEAE.

Hypericum virginicum L. Sp. Pl. ed. 2. 1104. 1763.

Bogs. Chisago City; Sandy lake. July, August. Nos. 683, 785.

Hypericum ascyron L. Sp. Pl. 783. 1753.

Copses. Minneapolis. July. No. 603.

Hypericum majus (A. GRAY) BRITT. Mem. Torr. Bot. Club. 5: 225. 1893–4.

Thompson; Minnetonka. July. Nos. 614, 626.

Hypericum ellipticum HOOK. Fl. Bor. Am. **1**: 110. 1830.

Moist places. Vermilion lake. July. No 478.

CISTACEAE.

Helianthemum canadense (L.) MICHX. Fl. Bor. Am. **1**: 308. 1803.

Copses, sandy soil. Cannon Falls; Minneapolis; Itasca county. July, August, September. Nos. 361, 752, 978.

Hudsonia tomentosa NUTT. Gen. **2**: 5. 1818.

Sandy soil. Cannon Falls. No. 363.

Lechea leggettii BRITTON and HOLLICK. Prel. Cat. N. Y. 6. 1888.

Copses, sandy soil. Centerville; Grand Rapids. July, August. Nos. 701, 740.

VIOLACEAE.

Viola blanda WILLD. Hort. Berol. *t. 24*. 1806.

Swamps, woods. Thompson. May, July. Nos. 88, 148, 559, 1157.

Viola blanda WILLD. var. **renifolia** A. GRAY. Bot. Gaz. **11**: 255. 1886.

Deep ravines. Thompson; Two Harbors. May, July. Nos. 92, 534.

Viola blanda var. **amoena** (LECONTE) B. S. P. Prel. Cat. N. Y. 6. 1888.

Woods. Aitkin county. August. No. 836.

Viola canadensis L. Sp. Pl. 936. 1753.
Rich woods. Pokegama lake islands; Silver creek. June. Nos. 23, 176, 206, 1132.

Viola labradorica SCHRANK. Denkschr. Bot. Ges. Regensb. **2**: 12. 1818.
Low grounds, woodland. Merriam Park; Grand Rapids; lake Itasca. May, June, August. Nos. 51, 67, 731, 1076.

Viola canina L. Sp. Pl. 935. 1753.
In crevices of slate rock. N. P. Junction. May. Nos. 4, 97.

Viola lanceolata L. Sp. Pl. 934. 1753.
Low grounds. Long lake. May. No. 56.

Viola obliqua HILL. Hort. Kew. 316. *t. 12.* 1769.
Thompson. May. No. 15.

Viola pedata L. Sp. Pl. 933. 1753.
Prospect Park. May. No. 2.

Viola pubescens AIT. Hort. Kew. **3**: 290. 1789.
Woods. Thompson; Fort Snelling. May, June. Nos. 44, 187.

Viola sagittata AIT. Hort. Kew. **3**: 287. 1789.
Low grounds, and crevices of rocks. N. P. Junction; Long lake; Centerville. May, July. Nos. 57, 65, 706.

LYTHRACEAE.

Lythrum alatum PURSH. Fl. Am. Sept. 334. 1814.
River banks. Cannon Falls. July. No. 377.

ONAGRACEAE.

Epilobium adenocaulon HAUSSKN. var. **perplexans** TRELEASE. Rep. Missouri Bot. Gard. **2**: 96. 1891.
Rich woods, sand shores. Minnetonka; Silver creek; lake Itasca. July, August. Nos. 625, 913, 1166.

Epilobium coloratum MUHL. Willd. Enum. **1**: 441. 1809.
Shores. Center City; Sandy lake. July, August. Nos. 662, 773.

Epilobium lineare MUHL. Cat. 39. 1813.
Bogs, wet places. Center City; Minneapolis. July, September. Nos. 663, 984.

Epilobium palustre L. Sp. Pl. 348. 1753.
A hybrid form. Bogs. Minneapolis. September. No. 983.

Chamaenerion angustifolium (L.) Scop. Fl. Carn. ed. 2. **1**: 271. 1772.

Waste places. Two Harbors; N. P. Junction; lake Itasca ("everywhere"). July, August. Nos. 254, 923, 1176.

Onagra albicaulis (Pursh) Britt. Mem. Torr. Bot. Club. **5**: 234. 1893–4.

Sandy soil. Minneapolis. July. No. 572.

Onagra biennis (L.) Scop. Fl. Carn. ed. 2. **1**: 269. 1772.

Dry borders, waste places. Thompson; Sandy lake; lake Itasca. July, August. Nos. 542, 806, 1155.

Oenothera rhombipetala Nutt. T. and G. Fl. N. A **1**: 493. 1840.

Sandy soil. Minneapolis. September. No. 954.

Kneiffia pumila (L.) Spach. Hist. Veg. **4**: 377. 1835.

Wet sandy soil Vermilion lake; Sandy lake. July, August. Nos. 486, 774.

Meriolix serrulata (Nutt.) Walp. Rep. **2**: 79. 1843.

Sterile hills. Minneapolis. June, July. Nos. 277, 592.

Circaea alpina L. Sp. Pl. 9. 1753.

Rich moist woods. Thompson; Silver creek; lake Itasca. June to August. Nos. 417, 910, 1092.

Circaea lutetiana L. Sp. Pl 9. 1753.

Copses and woods. Center City. July. No. 661.

HALORRHAGIDACEAE.

Hippuris vulgaris L. Sp. Pl. 4. 1753.

Ditches. Vermilion. July. No. 515.

Myriophyllum spicatum L. Sp. Pl. 992. 1753.

Ponds. Partridge river; Minnetonka; Sandy lake. July, August. Nos. 528, 639, 802.

ARALIACEAE.

Aralia hispida Vent. Hort. Cels. *t. 41.* 1800.

Rocky places. Thompson. July. No. 398.

Aralia nudicaulis L. Sp. Pl. 274. 1753.

Copses and wooded bluffs. Thompson; Minneapolis; lake Itasca. June, July, September (fruit). Nos. 125, 619, 973, 1199.

Aralia racemosa L. Sp. Pl. 273. 1753.
Copses, borders of woods. Aitkin county; lake Itasca. July, August. Nos. 1003, 1171.

Panax trifolium L. Sp. Pl. 1059. 1753.
Rich woods. Thompson. May. No. 77.

UMBELLIFERAE.

Heracleum lanatum Michx. Fl. Bor. Am. **1**: 166. 1803.
Meadows. Vermilion lake. July. No. 495.

Thaspium trifoliatum (L.) Britt. var. **aureum** (Nutt.) Britt. Mem. Torr. Bot. Club. **5**: 240. 1893–4.
Meadows. Thompson. July. No. 412.

Sanicula marylandica L. Sp. Pl. 235. 1753.
Copses, and along streams. Thompson; lake Itasca. July. Nos. 424, 1184.

Osmorrhiza claytoni (Michx.) B. S. P. Prel. Cat. N. Y. 21. 1888.
Woods along streams. Lakes Pokegama and Itasca. June, July. Nos. 213, 1159.

Sium cicutaefolium J. F. Gmel. Syst. **2**: 482. 1791.
Wet meadows. Minneapolis. September. No. 980.

Zizia aurea (L.) Koch. Nov. Act. Caes. Leop. Acad. **12**: 129. 1825.
Meadows. Minneapolis. June. No. 269.

Zizia cordata (Walt.) DC. Prodr. **4**: 100. 1830.
Sterile hills. Cannon Falls. June. No. 346.

Cicuta bulbifera L. Sp. Pl. 255. 1753.
Rich wet meadows. Grand Rapids. August. No. 727.

Cicuta maculata L. Sp. Pl. 256. 1753.
Low ground. Grand Rapids. August. No. 729.

Deringa canadensis (L.) Kuntze. Rev. Gen. Pl. 266. 1891.
Copses. Cannon Falls. July. No. 339.

CORNACEAE.

Cornus canadensis L. Sp. Pl. 118. 1753.
Woods and swamps. Thompson; Grand Rapids; lake Itasca. June, August (fruit). Nos. 136, 739, 1011.

Cornus circinata L'Her. Corn. 7. 1788.
Copses. Lake Pokegama; Minnetonka; lake Itasca. June, July. Nos. 229, 620, 1083.

Cornus candidissima Marsh. Arb. Am. 35. 1785.
River banks. Thompson. June. No. 134.

Cornus stolonifera Michx. Fl. Bor. Am. **1**: 92. 1803.
Wet places, along streams. Thompson; lake Itasca. June, July. Nos. 132, 547, 1192.

PYROLACEAE.

Chimaphila umbellata (L.) Nutt. Gen. **1**: 274. 1818.
Sandy soil, in pine woods. Cannon Falls; Aitkin county; lake Itasca. July, August. Nos. 362, 820, 1183.

Pyrola chlorantha Swartz. Act. Holm. 1810. *t. 5.* 1810.
Dry woods. Sugar brook; Aitkin; lake Itasca. June, August (fruit). Nos. 219, 823, 1197.

Pyrola elliptica Nutt. Gen. **1**: 273. 1818.
Copses and woods. Cannon Falls; Centerville; Grand Rapids; lake Itasca. July, August (fruit). Nos. 354, 700, 718, 1156.

Pyrola minor L. Sp. Pl. 396. 1753.
Woods. Grand Rapids. August (fruit). No. 738.

Pyrola rotundifolia L. Sp. Pl. 396. 1753.
Dry woods. Thompson; Aitkin county. July, August (fruit). Nos. 556, 822.

Pyrola rotundifolia L. var. **incarnata** DC. Prodr. **7**: 773. 1839.
Bogs. Lake Pokegama island; lake Itasca. June. Nos. 230, 1047.

Pyrola rotundifolia var. **pumila** Hornem. Plantel. ed. 3. **1**: 463. 1821.
Sphagnum swamps and woods. Aitkin county; lake Itasca. July, August. Nos. 825, 1196.

Pyrola secunda L. Sp. Pl. 396. 1753.
Pine woods. Thompson; Aitkin county; lake Itasca. July, August (fruit). Nos. 555, 824, 1121.

Moneses uniflora (L.) A. Gray. Man. 273. 1848.
Moist rich woods. Two Harbors; Silver creek; lake Itasca. June, August (fruit). Nos. 540, 909, 1012.

MONOTROPACEAE.

Monotropa uniflora L. Sp. Pl. 387. 1753.
Rich woods. Silver creek. August. No. 912.

ERICACEAE.

Ledum groenlandicum OEDER. Fl. Dan. *t. 567.* 1771.
Bogs. N. P. Junction; Vermilion lake; lake Itasca. June, July. Nos. 255, 471, 1045.

Kalmia glauca AIT. Hort. Kew. **2**:64. *t. 8.* 1811.
Bogs. Head of St. Louis river; Vermilion lake. May, July (fruit). Nos. 106, 469.

Andromeda polifolia L. Sp. Pl. 393. 1753.
Bogs. Vermilion lake; lake Itasca. Nos. 470, 1043.

Chamaedaphne calyculata (L.) MOENCH. Meth. 457. 1794.
Bogs. St. Louis river; Sandy lake. May, August (fruit). Nos. 109, 794.

Epigaea repens L. Sp. Pl. 395. 1753.
Sandy soil. N. P. Junction; lake Itasca. May, June. Nos. 10, 167, 1033.

Gaultheria procumbens L. Sp. Pl. 395. 1753.
Sandy soil, in pine woods. N. P. Junction; Grand Rapids; lake Itasca. June, August (fruit). Nos. 160, 721, 1094.

Chiogenes hispidula (L.) TORR. and GRAY. Torr. Fl. N. Y. **1**: 450. 1843.
Bogs. Thompson. May. No. 84.

Arctostaphylos uva-ursi (L.) SPRENG. Syst. **2**: 287. 1825.
Dry rocky ridges and sandy woods. Two Harbors; Sandy lake; lake Itasca. June to August. Nos. 464, 805, 1077.

Vaccinium canadense RICH. App. Frankl. Jour. ed. 2. 12. 1823.
Bogs and woods. Thompson; Aitkin county. May, August (fruit). Nos. 81, 826.

Vaccinium pennsylvanicum LAM. Ency. Meth. **1**: 74. 1783.
Dry sandy hillsides. Long lake; lake Itasca. May, June. Nos. 55, 1075.

Schollera macrocarpa (AIT.) BRITT. Mem. Torr. Bot. Club. **5**: 253. 1893-4.
Bogs. Chisago City. July (fruit). No. 687.

Schollera oxycoccus (L.) ROTH. Tent. Fl. Germ. **1**: 170. 1788
Bogs. Lakes Vermilion, Itasca; Chisago City. June, July (fruit). Nos. 472, 688, 1051.

PRIMULACEAE.

Primula farinosa L. Sp. Pl. 143. 1753.
Wet rocks. Thompson; Two Harbors. May, July (fruit). Nos. 26, 459.

Lysimachia terrestris (L.) B. S. P. Prel. Cat. N. Y. 34. 1888.
Wet ground. Center City. July. Nos. 646, 698.

Steironema ciliatum (L.) BAUDO. Ann. Sci. Nat. Bot. (II) **20**: 346. 1843.
Copses. Thompson; Aitkin county; lake Itasca. July, August (fruit). Nos. 393, 844, 1172.

Steironema lanceolatum (WALT.) A. GRAY. Proc. Am. Acad. **12**: 63. 1876.
Wet places. Center City. July. No. 673.

Naumburgia thyrsiflora (L.) DUBY. DC. Prodr. **8**: 60. 1844.
Sloughs. Lakes Itasca and Pokegama. June. Nos. 212, 1066.

Trientalis americana PURSH. Fl. Am. Sept. 254. 1814.
Swamps and woods. Thompson; Aitkin county; lake Itasca. June, August (fruit). Nos. 146, 834, 1123.

OLEACEAE.

Fraxinus americana L. Sp. Pl. 1057. 1753.
Woods. Thompson. July (fruit). No. 384.

GENTIANACEAE.

Gentiana andrewsii GRISEB. Hook. Fl. Bor. Am. **2**: 55. 1834.
Copses. Minneapolis. September. No. 981.

Gentiana crinita FROEL. Gent. 112. 1796.
Copses. Morrison county. August. No. 877.

Gentiana puberula MICHX. Fl. Bor. Am. **1**: 176. 1803.
Sterile hills. Minneapolis. September. No. 958.

Gentiana serrata GUNNER. Fl. Norv. 10. 1766.
Wet meadows. Minneapolis. September. No. 956.

Tetragonanthus deflexus (S. E. SMITH) KUNTZE. Rev. Gen. Pl. 431. 1891.
Rocky copses and shady woods. Two Harbors; Grand Rapids; Silver creek; lake Itasca. July, August (fruit). Nos. 457, 719, 908, 1151.

Menyanthes trifoliata L. Sp. Pl. 145. 1753.
Bogs. Two Harbors; lake Itasca. June, July. Nos. 450, 1042.

APOCYNACEAE.

Apocynum androsaemifolium L. Sp. Pl. 213. 1753.
Copses. Thompson; lake Itasca. June, July. Nos. 388, 1087.

ASCLEPIADACEAE.

Acerates viridiflora (Raf.) Eaton. Man. ed. 5. 90. 1829.
Sandy hills. Cannon Falls. July. No. 374.

Asclepias incarnata L. Sp. Pl. 215. 1753.
Wet meadows. Minneapolis. September. No. 952.

Asclepias ovalifolia Decsne. DC. Prodr. 8: 567. 1844.
Sandy soil. Minneapolis; lake Itasca. June, July. Nos. 284, 1127.

Asclepias exaltata (L.) Muhl. Cat. 28. 1813.
Copses. Cannon Falls. July. No. 358.

Asclepias tuberosa L. Sp. Pl. 217. 1753.
Sandy soil. Minneapolis. June, September (fruit). Nos. 306, 991, 1009.

CONVOLVULACEAE.

Convolvulus sepium L. Sp. Pl. 153. 1753.
Copses. Thompson. July. No. 389.

Convolvulus spithamaeus L. Sp. Pl. 158. 1753.
Sandy soil. Vermilion; Park Rapids. June, July. Nos. 485, 1237.

Cuscuta gronovii Willd. R. & S. Syst. 6: 205. 1820.
On Laportea. Aitkin county. August. No. 841.

POLEMONIACEAE.

Phlox divaricata L. Sp. Pl. 152. 1753.
Rich low woods. Minneapolis. June. No. 261.

Phlox pilosa L. Sp. Pl. 152. 1753.
Copses and dry prairies. Cannon Falls; Park Rapids. June July. Nos. 350, 1141.

Polemonium reptans L. Syst. ed. 10. no. 1. 1759.
Copses. Cannon Falls. June. No. 328.

HYDROPHYLLACEAE.

Hydrophyllum virginicum L. Sp. Pl. 146. 1753.
Rich woods. Minneapolis. May. No. 118.

Phacelia franklinii (R. Br.) A. Gray. Man. ed. 2. 329. 1856.
Along railway track Vermilion lake. July. No. 482.

BORAGINACEAE.

Cynoglossum virginicum L. Sp. Pl. 134. 1753.
Rich copses. Grand Rapids; lake Itasca. June, August. Nos. 734, 1063.

Lappula lappula (L.) Karst. Deutsch. Fl. 979. 1880–83.
Sandy soil. Minneapolis. July. No. 582.

Lappula texana (Scheele) Britt. Mem. Torr. Bot. Club. 5:273. 1893–4.
Sandy soil. Minneapolis. June. No. 286.

Lappula virginica (L.) Greene. Pitt. **2**:182. 1891.
Copses. Minneapolis. July. No. 590.

Mertensia paniculata (Ait.) Don. Gard. Dict. **4**:318. 1838.
Shady woods. Two Harbors. May, July (fruit). Nos. 104, 448.

Onosmodium carolinianum (Lam.) A. DC. Prodr. **10**:70. 1846.
Sandy soil. Cannon Falls. June. No. 341.

Lithospermum angustifolium Michx. Fl. Bor. Am. **1**:130. 1803.
Sandy meadows and hillsides. Prospect Park; Minneapolis; Cannon Falls. May to July. Nos. 52, 265, 369.

Lithospermum gmelini (Michx.) A. S. Hitchcock. Spring Fl. Manh. 30. 1894.
Sandy soil. Minneapolis. June. No. 289.

VERBENACEAE.

Phryma leptostachya L. Sp. Pl. 601. 1753.
Copses. Minnetonka. July. No. 618.

Verbena bracteosa Michx. Fl. Bor. Am. **2**:13. 1803.
Sandy soil. Minneapolis. June. No. 267.

Verbena hastata L. Sp. Pl. 20. 1753.
Sandy river banks. Grand Rapids; lake Itasca. July, August. Nos. 712, 1253.

Verbena stricta VENT. Hort Cels. *t. 53.* 1800.
Sandy soil. Minneapolis. June. No. 266.

Verbena stricta X hastata.
Sterile hills. Minneapolis. July. No. 605.

Verbena urticaefolia L. Sp. Pl. 20. 1753.
Waste places. Minneapolis. July. No. 597.

LABIATAE.

Mentha canadensis L. Sp. Pl. 577. 1753.
Wet places. Lakes Vermilion and Itasca. June, July. Nos. 508, 1073

Lycopus sinuatus ELL. Bot. S. C. & Ga. **1**: 126. 1816.
Low moist shores. Minneapolis; Center City; Itasca county. July, August. Nos. 606, 655, 755.

Lycopus virginicus L. Sp. Pl. 21. 1753.
Moist shores. Itasca county. August. No. 756.

Koellia virginiana (L.) MACM. Met. Minn. Vall. 452. 1892.
Copses. Minneapolis. July. No. 599.

Hedeoma hispida PURSH. Fl. Am. Sept. 414. 1814.
Sandy soil. Minneapolis. June. No. 287.

Monarda fistulosa L. Sp. Pl. 22. 1753.
Copses. Center City. July. No. 643.

Monarda scabra BECK. Am. Jour. Sci. **10**: 260. 1826.
Copses. Sandy lake. August. No. 795.

Vleckia anethiodora (NUTT.) GREENE. Mem. Torr. Bot. Club. **5**: 282. 1893–4.
Copses and bluffs. Minneapolis; lake Itasca. June, July. Nos. 595, 1030.

Vleckia scrophulariaefolia (WILLD.) RAF. Fl. Tell. **3**: 89. 1836.
Copses. Chisago City. July. No. 678.

Dracocephalum parviflorum NUTT. Gen. **2**: 35. 1818.
Sandy bluffs. Cannon Falls; lake Itasca. June. Nos. 332, 1031.

Scutellaria galericulata L. Sp. Pl. 599. 1753.
Sloughs. Lakes Vermilion and Itasca. June, July. Nos. 513, 1064.

Scutellaria lateriflora L. Sp. Pl. 598. 1753
Wet places. Center City. July. No. 664.

Scutellaria parvula Michx. Fl. Bor. Am. **2**: 11. 1803.
Sandy soil. Minneapolis. June. No. 301.

Prunella vulgaris L. Sp. Pl. 600. 1753.
Copses. Thompson. July. No. 410.

Physostegia virginiana (L.) Benth. Lab. Gen. Sp. 504. 1834.
River banks. Itasca and Aitkin county. August. Nos. 753, 1000.

Stachys palustris L. Sp. Pl. 580. 1753.
Wet sandy shores. Lakes Vermilion and Itasca. June, July. Nos. 484, 1105.

SOLANACEAE.

Solanum nigrum L. Sp. Pl. 186. 1753.
Waste places. Sandy lake. August. No. 776.

Physalis grandiflora Hook. Fl. Bor. Am. **2**: 90. 1834.
Rich moist soil. Pokegama lake; lake Itasca. June. Nos. 201, 1070.

Physalis lanceolata Michx. Fl. Bor. Am. **1**: 149. 1803.
Sandy soil. Minneapolis. June. No. 271.

Physalis viscosa L. Sp. Pl. 183. 1753.
Sandy soil. Minneapolis. September. No. 975.

SCROPHULARIACEAE.

Linaria linaria (L.) Karst. Deutsch. Fl. 947. 1880–83.
Copses. Minneapolis. July. No. 596.

Scrophularia marilandica L. Sp. Pl. 619. 1753.
Copses. Minneapolis. July. No. 598.

Chelone glabra L. Sp. Pl. 611. 1753.
Wet meadows. Two Harbors. August. No. 892.

Pentstemon gracilis Nutt. Gen. **2**: 52. 1818.
Sandy fields. Minneapolis; Grand Rapids. June, August (fruit). Nos. 302, 732.

Pentstemon grandiflorus Nutt. Fras. Cat. 1813.
Sandy soil. Cannon Falls. June. Nos. 335, 336.

Pentstemon hirsutus (L.) Willd. Sp. Pl. **3**: 227. 1801.
Sandy soil. Park Rapids. June. No. 1238.

Mimulus jamesii Torr. & Gray. Benth. in DC. Prodr. **10**: 371. 1846.
Springs. Cannon Falls; Itasca county. July, August. Nos. 376, 746.

Mimulus ringens L. Sp. Pl. 634. 1753.
River banks. Crow Wing county; Vermilion lake. July, August (fruit). Nos. 479, 853.

Wulfenia houghtoniana (BENTH.) GREENE. Erythea. **2**: 83. 1894.
Dry prairies. Cannon Falls. July. No. 373.

Veronica americana SCHWEIN. Benth. in DC. Prodr. **10**: 468. 1846.
Wet places, along streams. Lake Itasca. July. No. 1170.

Veronica anagallis-aquatica L. Sp. Pl. 12. 1753.
Wet places. Sandy lake. August. No. 995.

Veronica peregrina L. Sp. Pl. 14. 1753.
Wet places. Thompson. July. No. 405.

Veronica scutellata L. Sp. Pl. 12. 1753.
Sloughs. Lakes Pokegama and Itasca. June, July. Nos. 203, 1162.

Veronica serpyllifolia L. Sp. Pl. 12. 1753.
Low grounds. Thompson. June. No. 190.

Leptandra virginica (L.) NUTT. Gen. **1**: 7. 1818.
Copses. Minneapolis. July, September (fruit). Nos. 585, 932.

Gerardia purpurea L. Sp. Pl. 610. 1753.
Shores. Morrison county. August. No. 883.

Gerardia tenuifolia VAHL. Symb. Bot. **3**: 79. 1794.
Shores. Sandy lake. August. No. 763.

Castilleja coccinea (L.) SPRENG. Syst. **2**: 775. 1825.
Wet shady places. Grand Rapids; lake Itasca. June, August. Nos. 728, 1022.

Castilleja sessiliflora PURSH. Fl. Am. Sept. 738. 1814.
Sandy hillsides. Cannon Falls. July (fruit). No. 371.

Euphrasia officinalis L. Sp. Pl. 604. 1753.
Crevices of rocks. Two Harbors. July, August (fruit). Nos. 435, 898.

Pedicularis canadensis L. Mant. 86. 1767.
Copses. Lake Itasca. June. No. 1103.

Pedicularis lanceolata MICHX. Fl. Bor. Am. **2**: 18. 1803.
Wet meadows. Minneapolis. September. No. 939.

Melampyrum lineare LAM. Ency. Meth. **4**: 22. 1797.
Pine woods. Grand Rapids. August. No. 720.

LENTIBULARIACEAE.

Utricularia intermedia HAYNE. Schrad. Jour. Bot. **1**: 18. 1800.

In water. Partridge river; St. Louis county. July. No. 516.

Utricularia vulgaris L. Sp. Pl. 18. 1753.

In water. Lakes Vermilion and Itasca. July. Nos. 476, 1181.

PLANTAGINACEAE.

Plantago major L. Sp. Pl. 112. 1753.

Along trails. Lake Itasca. July. No. 1206.

RUBIACEAE.

Houstonia longifolia GAERTN. Fr. and Sem. **1**: 226. *t. 49. f. 8.* 1788.

Dry sandy and rocky soil. Thompson; Two Harbors; Sandy lake; Park Rapids. June, August (fruit). Nos. 129, 531, 764, 1240.

Mitchella repens L. Sp. Pl. 111. 1753.

Woods. Aitkin county. August (fruit). No. 837.

Galium asprellum MICHX. Fl. Bor. Am. **1**: 78. 1803.

Wet places. Pokegama lake. June. No. 218.

Galium boreale L. Sp. Pl. 108. 1753.

Copses. Minneapolis; Thompson; lake Itasca. June, July (fruit). Nos. 290, 545, 1021.

Galium trifidum L. Sp. Pl. 105. 1753.

Moist woods. Pokegama lake; Aitkin county; lake Itasca. June, August (fruit). Nos. 207, 840, 1056.

Galium triflorum MICHX. Fl. Bor. Am. **1**: 80. 1803.

Alluvial soil, in woods. Lakes Pokegama and Itasca. June. Nos. 215, 1091.

CAPRIFOLIACEAE.

Sambucus pubens MICHX. Fl. Bor. Am. 181. 1803.

Copses. Thompson; lake Itasca. May, July (fruit). Nos. 72, 611, 1086.

Viburnum opulus L. Sp. Pl. 268. 1753.

Copses and borders of bogs. Chisago City; lake Itasca. July. Nos. 686, 1191.

Triosteum perfoliatum L. Sp. Pl. 176. 1753.

Copses. Cannon Falls. July. No. 366.

Symphoricarpos occidentalis Hook. Fl. Bor. Am. **1**: 285. 1833.

Copses. Cannon Falls. June. No. 347.

Symphoricarpos pauciflorus (Robbins) Britt. Mem. Torr. Bot. Club. **5**: 305. 1893–4.

Lake Pokegama island; Sandy lake. June, August. Nos. 233, 777.

Linnaea borealis L. Sp. Pl. 631. 1753.

Edges of swamps. Pokegama lake; lake Itasca. June. Nos. 217, 1010

Lonicera coerulea L. Sp. Pl. 174. 1753.

Spruce swamps. Head of St. Louis river; lake Itasca. May, July. Nos. 108, 1200.

Lonicera ciliata Muhl. Cat. 23. 1813.

Copses. St. Louis river; Sugar brook; lake Itasca. May, June. Nos. 23, 227, 1037.

Lonicera dioica L. Syst. ed. 12. 165. 1767.

Copses. Minneapolis; lake Itasca. June, July. Nos. 621, 1061.

Lonicera hirsuta Eaton. Man. ed. 2. 307. 1818.

Lake Pokegama; Schoolcraft's island, lake Itasca. June. Nos. 236, 1023.

Diervilla diervilla (L.) MacM. Bull. Torr. Bot. Club. **19**: 15. 1892.

Lake Pokegama islands; Grand Rapids; lake Itasca. June, August (fruit). Nos. 231, 725, 1088.

ADOXACEAE.

Adoxa moschatellina L. Sp. Pl. 367. 1753.

Rich woods. N. P. Junction; Silver creek. May, June. Nos. 5, 90, 180.

VALERIANACEAE.

Valeriana edulis Nutt. Torr. and Gray. Fl. N. A. **2**: 48. 1841.

Rocky hills. Cannon Falls. June (fruit). No. 345.

CAMPANULACEAE.

Campanula aparinoides Pursh. Fl. Am. Sept. 159. 1814. var. **grandiflora** n. var.

Stem stouter than in the species. Corolla half inch long, *5 to 6 times* longer than the calyx lobes, blueish white, solitary,

terminating the rigid ascending branches which are 2 to 4 inches long.

Wet places. Vermilion. July. No. 506.

Campanula rotundifolia L. Sp. Pl. 163. 1753.

Dry sandy hills. Lake Itasca; Grand Rapids. June to August. Nos. 717, 1089.

Campanula rotundifolia L. var. **langsdorfiana** (A. DC.) BRITT. Mem. Torr. Bot. Club. 5:309. 1893–4.

Rocks. Two Harbors. July. No 442.

Lobelia kalmii L. Sp. Pl. 930. 1753.

Sandy moist shores. Hubbard and Morrison counties. July, August. Nos. 880, 1226.

Lobelia spicata LAM. Ency. Meth. 3:587. 1789.

Meadows. Centerville. July. No. 705.

Lobelia syphilitica L. Sp. Pl. 931. 1753.

Moist places. Morrison county. August. No. 881.

COMPOSITAE.

Vernonia fasciculata MICHX. Fl. Bor. Am. 2:94. 1803.

Shores. Sandy lake. August. No. 762.

Eupatorium ageratoides L. f. Suppl. 355. 1781.

Copses. Minnehaha falls. September. No. 950.

Eupatorium perfoliatum L. Sp. Pl. 838. 1753.

Bogs. Sandy lake. August. No. 792.

Eupatorium purpureum L. Sp. Pl. 838. 1753.

Moist meadows. Aitkin county. August. No. 843.

Kuhnia eupatorioides L. Sp. Pl. ed. 2. 1662. 1763.

Sand hills. Minnehaha falls. September. No. 946.

Laciniaria punctata (HOOK.) KUNTZE. Rev. Gen. 349. 1891.

Sterile hills. Minneapolis. September. No. 933.

Laciniaria scariosa (L.) HILL. Veg. Syst. 4:49. 1762.

Sandy soil. Grand Rapids. August. No. 741.

Grindelia squarrosa (PURSH) DUNAL. DC. Prodr. 5:315. 1836.

Waste places. Brainerd. August. No. 868.

Chrysopsis villosa (PURSH) NUTT. Gen. 2:151. 1818.

Sandy soil. Minneapolis. June. No. 292.

Solidago hispida MUHL. Willd. Sp. Pl. 3:2063. 1804.

Copses and pine woods. Grand Rapids; N. P. Junction. August, September. Nos. 715, 925.

Solidago canadensis L. Sp. Pl. 878. 1753.
Copses. Silver creek. August. No. 906.

Solidago juncea AIT. Hort. Kew. **3**:213. 1789.
Dry copses, pine woods. Grand Rapids; lake Itasca. July. Nos. 726, 1204.

Solidago flexicaulis L. Sp. Pl. 879. 1753.
Moist copses. Two Harbors. August. No. 891.

Solidago missouriensis NUTT. Jour. Acad. Phil. **7**:32. 1834.
Sandy copses, and rocky soil. Thompson; Minneapolis; Centerville. July. Nos. 411, 576, 709.

Solidago nemoralis AIT. Hort. Kew. **3**:213. 1789.
Dry hills. Sandy lake; Morrison county. August. Nos. 765, 874.

Solidago riddellii FRANK. Ridd. Syn. Fl. W. St. 57. 1835.
Moist places. Minneapolis. September. No. 959.

Solidago rigida L. Sp. Pl. 880. 1753.
Sandy soil. Morrison county. August. No. 872.

Solidago serotina AIT. Hort. Kew. **3**:211. 1789.
Wet copses. Center City; Aitkin county. July, August. Nos. 668, 1004.

Solidago speciosa NUTT. Gen. **2**:160. 1818.
Copses. Brainerd; Minneapolis. August, September. Nos. 865, 997.

Solidago uliginosa NUTT. Jour. Acad. Phil. **7**:101. 1834.
Bogs. Sandy lake. August. No. 786.

Euthamia graminifolia (L.) NUTT. Gen. **2**:162. 1818.
Shores. Center City. July. No. 667.

Aster azureus LINDL. Hook. Comp. Bot. Mag. **1**:89. 1835.
Copses. Crow Wing county. August. No. 854.

Aster lateriflorus (L.) BRITT. Trans. N. Y. Acad. Sci. **9**:10. 1889.
Copses. Aitkin county. August. Nos. 817, 1002, 1006.

Aster junceus AIT. Hort. Kew. **3**:204. 1789.
Moist ground and bogs. Sandy lake; Minneapolis. August, September. Nos. 665 (?), 787, 989 (?).

Aster laevis L. Sp. Pl. 876. 1753.
Copses and woods. Grand Rapids; Minneapolis. August, September. Nos 716, 736, 996.

Aster lindleyanus TORR. and GRAY. Fl. N. A. 2:122. 1841.
Copses. Sandy lake. August. No. 788.

Aster macrophyllus L. Sp. Pl. ed. 2. 1232. 1763.
Copses. Sandy lake; N. P. Junction. August, September, Nos. 804, 927.

Aster majus (HOOK.) PORTER. Mem. Torr. Bot. Club. 5:325. 1893–4. Approaching *A. novae-angliae.*
Wet places. N. P. Junction. September. No. 928.

Aster multiflorus AIT. Hort. Kew. 3:203. 1789.
Dry soil. Minneapolis. September. No. 966.

Aster novae-angliae L. Sp. Pl. 875. 1753.
Copses. Center City; Minneapolis. September. Nos. 665 (?), 974, 979.

Aster oblongifolius NUTT. var. **rigidulus** GRAY. Syn. Fl. N. A. 1: pt. 2. 179. 1886.
Sterile hills. Minneapolis. September. No. 935.

Aster ptarmicoides (NEES.) TORR. and GRAY. Fl. N. A. 2:160. 1841.
Sandy hills, and crevices of rocks. Crow Wing; Two Harbors. August. Nos. 861, 901.

Aster puniceus L. Sp. Pl. 875. 1753.
Wet places. Two Harbors; Minneapolis. August, September. Nos. 894, 965, 986

Aster sagittifolius WEDEM. Willd. Sp. Pl. 3:2035. 1804.
Copses. Crow Wing; Minneapolis. August, September. Nos. 858, 982.

There are two forms under this species. No. 982 has *blue* rays and heads, in a short panicle; No. 858 has rays almost white, with heads in a more elongated panicle. Also, the root leaves in 982 are broader than in 858.

Aster salicifolius LAM. Ency. Meth. 1:306. 1783.
Shores and woods. Sandy lake; Two Harbors. August. Nos. 761, 897.

Aster sericeus VENT. Hort. Cels. *t. 33.* 1800.
Sandy soil. Minneapolis. September. No. 938.

Aster umbellatus MILL. Gard. Dict. ed. 8. no. 22. 1768.
Moist copses. Crow Wing county. August. No. 855.

NOTE.—This series of Northern Minnesota Asters contains a number of puzzling forms. Thus, under No. 989, the collector

had a series of plants, evidently brought together correctly, the larger forms of which are *Aster junceus*. Some of the forms approach closely to specimens of *Aster salicifolius* var. *subasper*. When more slender and fewer-headed, as in some of these specimens, the plant agrees very well with Pringle's *Aster laxifolius* NEES, var. *longifolius* LAM., from Vermont. And the smallest specimens of the series under this number could not be distinguished from Pringle's *Aster ericoides*, var. *pringlei* GRAY, from lake Champlain. (The Synoptical Flora give lake Champlain as the only station known for this var. *pringlei*. But among the "unknowns" in the National Herbarium I found a plant collected in 1868 by Dr. Vasey, in Colorado, which agrees in every respect with this *Aster ericoides*, var. *pringlei*; except that the heads are less developed.) Again, some of the plants under No. 761, *Aster salicifolius* AIT., approach *Aster junceus* AIT. No. 665, of which unfortunately only two plants were found, has the large heads and the mode of branching of *A. novi-belgii* L., but has the lower stem and leaves of *Aster junceus* AIT., where it was finally allowed to rest. Under *Aster puniceus*, No. 894 is considered the typical form. It is much less common in southern Minnesota than the form No. 986, which is bushier, with leaves denser and broader, and agrees well with Pringle's Vermont plant. No. 928, referred above to the western *Aster modestus*, is possibly a hybrid between *Aster puniceus* and *novae-angliae*. *Aster macrophyllus* L. occurs in two forms. No. 804 is the larger, less canescent, with larger, thinner leaves. No. 927, being shorter, stouter, more canescent, with thicker leaves, approaches the western *Aster radulinus*, from which, however, it differs in its more scarious involucral bracts, and its quite glabrous longer akenes.

An unqualified specific reference of some of these Asters is not possible.

Erigeron annuus (L.) PERS. Syn. 2: 431. 1807.
Copses. Cannon Falls. June. No. 329.

Erigeron canadensis L. Sp. Pl. 863. 1753.
Below Grand Rapids. August. No. 742.

Erigeron philadelphicus L. Sp. Pl. 863. 1753.
Meadows. Thompson; lake Itasca. May, July. Nos. 121, 1129.

Erigeron ramosus (WALT.) B S. P. Prel. Cat. N. Y. 27. 1888.
Sandy soil. Minneapolis. July. No. 612.

Antennaria plantaginifolia (L.) RICH. App. Frank. Jour. ed 2. 30. 1823.

Dry hills. N. P. Junction; lake Itasca. May, June. Nos. 68, 1093.

Antennaria margaritacea (L.) HOOK. Fl. Bor. Am. **1**: 329. 1833.

Sandy soil. Sandy lake. August. No. 994.

Silphium laciniatum L. Sp. Pl. 919. 1753.

Sandy soil. Cannon Falls. June. No. 343.

Iva xanthiifolia (FRESEN.) NUTT. Trans. Am. Phil. Soc. (II) **7**: 347. 1841.

Waste places. Morrison county. August. No. 873.

Ambrosia artemisiaefolia L. Sp. Pl. 988. 1753.

Sandy soil. Minneapolis. September. No. 955.

Ambrosia psilostachya DC. Prodr. **5**: 526. 1836.

Road sides. N. P. Junction. August. No. 922.

Xanthium canadense MILL. Gard. Dict. ed. 8. No. 2. 1768.

Shores. Sandy lake. August. No. 772.

Heliopsis scabra DUNAL. Mem. Mus. Par. **5**: 56. *t. 4.* 1819.

Along streams. Partridge river; lake Itasca. July. Nos. 517, 1198.

Lepachys columnaris (PURSH) TORR. and GRAY. Fl. N. A. **2**: 315. 1842.

Sandy soil. Minneapolis. July. No. 566.

Lepachys pinnata (VENT.) TORR. and GRAY. Fl. N. A. **2**: 314. 1842.

Dry copses. Minneapolis. July. No. 583.

Rudbeckia hirta L. Sp. Pl. 907. 1753.

Sandy soil. Minneapolis. June. No. 309.

Rudbeckia laciniata L. Sp. Pl. 906. 1753.

Copses. Morrison county. August. No. 878.

Helianthus annuus L. Sp. Pl. 904. 1753.

Minneapolis. September. No. 969.

Helianthus giganteus L. Sp. Pl. 905. 1753.

Copses. Grand Rapids. August. No. 735.

Helianthus grosse-serratus MARTENS. Sel. Sem. Hort. Loven. 1839.

Copses. Minnehaha falls. September. No. 941.

Helianthus maximiliani SCHRAD. Ind. Sem. Hort. Goett. 1835.
Waste places. N. P. Junction. September. No. 924.

Helianthus occidentalis RIDDELL. Suppl. Pl. Ohio. 13. 1836.
Sandy copses. Centerville. July. No. 699.

Helianthus petiolaris NUTT. Jour. Acad. Phil. **2**: 115. 1821.
Sandy soil. Minneapolis. July. No. 586.

Helianthus rigidus DESF. Cat. Hort. Par. **3**: 184. 1813.
Copses. Morrison county. August. Nos. 871, 885.

Helianthus strumosus L. Sp. Pl. 905. 1753.
Copses. Sandy lake. August. No. 791.

Helianthus tracheliifolius MILL. Gard Dict. ed. 8. No. 7. 1768.
A hybrid. Copses. Minnehaha falls. September. No. 942.

Coreopsis palmata NUTT. Gen. **2**: 180. 1818.
Dry prairies. Cannon Falls. July.

Bidens trichosperma (MICHX.) BRITT. Bull. Torr. Bot. Club. **20**: 281. 1893.
Wet places. Minneapolis. September. No. 936.

Bidens beckii TORR. Spreng. Neue. Entd. **2**: 135. 1821.
Ponds. Minnetonka. July. No. 634.

Bidens cernua L. Sp. Pl. 832. 1753.
Wet places. Minneapolis. September. No. 985.

Bidens laevis (L.) B. S. P. Prel. Cat. N. Y. 29. 1888.
River banks. Aitkin county. August. No. 842.

Bidens connata MUHL. Willd. Sp. Pl. **3**: 1718. 1804.
Wet places. Silver creek. August. No. 919.

Bidens connata MUHL. var. **pinnata** WATSON. Gray, Man. Bot. ed. 6. 284. 1890.
Wet places. Ramsey county. September. No. 929.

Bidens frondosa L. Sp. Pl. 832. 1753.
A small form. Wet places. Sandy lake. August. No. 769.

Madia glomerata HOOK. Fl. Bor. Am. **2**: 24. 1841.
N. P. Junction. September. No. 926.

Helenium autumnale L. Sp. Pl. 886. 1753.
River banks. Aitkin county. August. No. 850.

Achillea millefolium L. Sp. Pl. 899. 1753.
Waste places. Vermilion. July. No. 491.

Chrysanthemum leucanthemum L. Sp. Pl. 888. 1753.
Railway tracks; probably introduced. Thompson. July. No. 422.

Artemisia absinthium L. Sp. Pl. 848. 1753.
Chisago City. July. No. 674.

Artemisia caudata MICHX. Fl. Bor. Am. **2**: 129. 1803.
Sandy soil. Morrison county. August. No. 870.

Artemisia dracunculoides PURSH. Fl. Am. Sept. 742. 1814.
Dry copses. Minneapolis. September. No. 937.

Artemisia frigida WILLD. Sp. Pl. **3**: 1838. 1804.
Sandy hill sides. Morrison county. August. No. 869.

Artemisia gnaphalodes NUTT. Gen. **2**: 143. 1818.
Sandy shores. Sandy lake. August. No. 796.

Artemisia vulgaris L. Sp. Pl. 848. 1753.
Roadsides. Ramsey county. August. No. 711.

Tussilago palmata AIT. Hort. Kew. **2**: 188. *t. 2.* 1789.
Low swampy ground. Thompson; N. P. Junction; Crow Wing county; lake Itasca. May to July. Nos. 8, 25, 66, 103, 430, 857, 1034.

Tussilago sagittata PURSH. Fl. Am. Sept. 332. 1814.
Sloughs. N. P. Junction; lake Itasca. June, July. Nos. 155, 1249.

Cacalia atriplicifolia L. Sp. Pl. 835. 1753.
Low meadows. Cannon Falls. July. No. 367.

Cacalia tuberosa NUTT. Gen. **2**: 138. 1818.
Low meadows. Cannon Falls. July. No. 378.

Senecio aureus L. Sp. Pl. 870. 1753.
Sandy soil. Thompson. July. No. 421.

Senecio palustris (L.) HOOK. Fl. Bor. Am. **1**: 334. 1833.
Wet places. Two Harbors. July. No. 536.

Senecio tomentosus MICHX. Fl. Bor. Am. **2**: 119. 1803.
Hillsides. Lake Pokegama island; lake Itasca. June. Nos. 235, 1036.

Carduus altissimus L. Sp. Pl. 824. 1753.
Meadows. Crow Wing county. August. No. 860.

Carduus arvensis (L.) ROBS. Brit. Fl. 163. 1777.
Roadsides. Chisago City. July. No. 676.

Carduus muticus (MICHX.) PERS. Syn. **2**: 386. 1807.
Moist meadows. August. No. 760.

Carduus odoratus (MUHL.) PORTER. Mem. Torr. Bot. Club **5**: 345. 1893–4.
Meadows. Cannon Falls. July. No. 268.

Adopogon virginicum (L.) KUNTZE. Rev. Gen. Pl. 304. 1891.
Sandy ground. Cannon Falls; Park Rapids. July. Nos. 353, 1233.

Hieracium canadense MICHX. Fl. Bor. Am. **2**: 86. 1803.
Sandy soil. Grand Rapids. August. No. 723.

Hieracium scabrum MICHX. Fl. Bor. Am. **2**: 86. 1803.
Pine woods. Grand Rapids. August. No. 722.

Nothocalais cuspidata (PURSH) GREENE. Bull. Cal. Acad. (II) **2**: 55. 1886.
Sandy prairies. Fort Snelling. May. No. 49.

Agoseris glauca (PURSH) GREENE. Pitt. **2**: 176. 1891.
Prairies. Park Rapids. June. No. 1234.

Taraxacum taraxacum (L.) KARST. Deutsch. Fl. 1138. (1880–83.)
Minneapolis. May. No. 74.

Lactuca spicata LAM. A. S. Hitchc. Trans. St. Louis Acad. **5**: 506. 1891.
Dry soil. Minneapolis; Aitkin county. August, September. Nos. 951, 1007.

Lactuca scariola L. Sp. Pl. ed. 2. 1119. 1763.
Road sides. Minneapolis. September. No. 972.

Prenanthes alba L. Sp. Pl. 798. 1753.
Moist places. Crow Wing county. August. No. 856.

Prenanthes racemosa MICHX. Fl. Bor. Am. **2**: 84. 1803.
Copses. Minneapolis. September. No. 971.

Sonchus oleraceus L. Sp. Pl. 794. 1753.
Waste ground. Minneapolis. August. No. 993.

Lygodesmia juncea (PURSH) DON. Edin. Phil. Jour. **6**: 311. 1829.
Sandy soil. Minneapolis. July. No. 571.

XXXII. ESTIMATIONS OF THE CHANGES IN DRY WEIGHT OF LEAVES OF HELIANTHUS.

J. Thompson and W. W. Pendergast.

The experiments, the results of which are given below, were undertaken for the purpose of making a comparative estimate of the changes in the dry weight of leaves during periods of daylight and darkness, in connection with some extensive observations upon the variations and total amount of mineral matter in leaves stems and roots.

The material was taken entirely from the "Russian Sunflower," beginning at the time when the first heads were opening, July 21, and continuing for 18 days thereafter until August 8, 1895.

The following conditions were observed in the selection of material:

Perfect fully grown leaves, generally the fourth or fifth from the apex of the shoot, were used. Above this the leaves were in a state of rapid enlargement, and below this they were more or less injured by the action of the wind. By means of a piece of glass of the required size placed on the lower side of the leaf, and a sharp knife, fairly uniform areas of the leaf were obtained. Two samples of each leaf were taken, one on either side of the midrib, and equidistant from it and the base. As a check on the equality of the two pieces thus obtained, which were to be contrasted in every test, a number of pieces were cut from fresh leaves and weighed immediately, showing in no instance a variation of more than .0007 gram from the average, a variation too small to affect the general results presented below:

The first samples used were circular, 39.7 mm. in diameter, and later were increased to 48 mm. All samples were weighed as quickly as possible after separation from the leaf and then subjected to the heat of a water bath oven for two hours at 100°C. All samples were cut from the leaf at 7 A. M. and 7 P. M.

The tests were conducted in three series as follows:

1st. A sample was taken from the leaf on one side of the midrib in the evening, and the second from the opposite side in the morning, and their dry weights compared.

2nd. The first sample was taken in the morning and the second from the same leaf in the evening of the same day.

3rd. A portion of the leaf of the required area was covered by means of thin plates of cork, covered with black paper in the morning, and one sample was cut from this shaded area and another from the other half of the leaf lamina on the evening of the same day.

The data obtained from these series are arranged in Tables I, II and III respectively, and may be expressed briefly as follows:

I. Fifteen pairs of samples, taken between July 21 and August 1, showed an average loss in dry weight during the night amounting to 1.41 grams per square meter. In three of the tests an increase was noted. (See Table I.)

II. Ten pairs of samples, taken between July 27 and August 8, showed a gain in dry weight during the daytime amounting to 1.9 gram per square meter. (See Table II.)

III. Ten pairs of samples, obtained from July 26 to August 8, showed that the average gain in weight of the unshaded was greater than that of the shaded samples, in seven, and less in three of the tests. The gain in dry weight of the unshaded samples was at the rate of 1.44 grams per square meter. (See Table III.)

TABLE I.

Showing change in weight of dry matter during night.

DATES.	Weight of dry matter at night.	Weight of dry matter in morning.	Gain (+) or loss (—) during night.	Gain (+) or loss (—) per sq. meter during night (grams).
July 21-22 a	0.0683	0.0626	−0.0057	−4.66
July 21-22 b	0.0453	0.0447	−0.0006	−0.49
" 22-23 a	0.0537	0.0532	+0.0005	+0.41
" 22-23 b	0.0472	0.0444	−0.0028	−2.29
" 23-24 a	0.0566	0.0546	−0.0020	−1.64
" 23-24 b	0.0422	0.0402	−0.0020	−1.64
" 24-25 a	0.0697	0.0619	−0.0078	−6.38
" 24-25 b	0.0530	0.0477	−0.0053	−4.34
" 25-26 a	not taken	....	....	....
" 25-26 b	0.0528	0.0512	−0.0016	−1.31
" 26-27	0.0767	0.0810	+0.0043	+3.51
" 27-28*	0.0758	0.0880	+0.0122	+3.67
" 28-29	0.0967	0.0946	−0.0021	−0.63
" 29-30	0.0977	0.0890	−0.0087	−2.61
" 30-31	0.1000	0.0910	−0.0090	−2.71
" 31-Aug. 1	0.1024	0.0985	−0.0039	−1.17
Total of 15 samples	1.0371	1.0026	−0.0345	−21.23
Average of 15 samples	0.0691	0.0668	−0.0023	−1.41

*Size of sample increased from 39.7 mm. to 48 mm. in diameter.

TABLE II.

Showing change of weight in dry matter during day.

DATES.	Weight of dry matter in morning.	Weight of dry matter at night.	Gain (+) or loss (—) during day.	Gain (+) or loss (—) per sq. meter during day (grams).
July 27	0.0814	0.0873	+0.0059	+1.78
" 28	0.0985	0.0948	+0.0037	+1.11
" 29	0.0829	0.0820	−0.0009	−0.27
" 30	0.0940	0.0983	+0.0043	+1.23
" 31	0.0910	0.0920	+0.0010	+0.30
Aug. 1	not taken	....	....	....
" 2	0.1019	0.0987	−0.0042	−1.26
" 3	0.1029	0.1140	+0.0111	+3.34
" 4	0.0949	0.1075	+0.0126	+3.79
" 5	0.0800	0.0948	+0.0148	+4.45
" 6	not taken	....	....	....
" 7	not taken	....	....	....
" 8	0.0670	0.0770	+0.0100	+3.01
Total of 10 samples	0.8945	0.9464	+0.0519	+19.08
Average of 10 samples	0.0894	0.0946	+0.0052	+ 1.90

TABLE III.

Showing difference in weight of dry matter between equal areas of the same leaf, one portion being covered 10 hours previous to weighing, and the other exposed to light.

DATES.	Weight of dry matter of covered area.	Weight of dry matter of uncovered area.	Covered weighed more than uncovered	Uncover'd weighed more than covered.	PER SQUARE METER.	
					Covered weighed more than uncovered	Uncover'd weighed more than covered.
July 26	0.0467	0 0525	....	0.0058	....	5.76
" 27	0.0483	0.0566	....	0.0083	....	6.78
" 28	sample	injured	....	....	....	....
" 29*..........	0.0719	0.0818	....	0.0099	....	2.97
" 30	0.0876	0.0965	....	0.0089	....	2.67
" 31	0.0680	0.0765	....	0.0085	....	2.56
Aug. 1	sample	not take	n	....	....	....
" 2	0.1108	0.0965	0.0143	....	4.30	....
" 3	0.0850	0 0765	0.0085	....	2.55	....
" 4-5.........	sample	not take	n	....	....	....
" 6	0.0880	0.0966	....	0.0086	....	2.58
" 7	0.0852	0 0755	0.0097	....	2.91	....
" 8	0.0915	0.0945	....	0.0030	....	0.90
Total of 10 samp's	0.7830	0.8035	....	0.0205	....	14.46
Av. of 10 samples	0.0783	0.0803	....	0.0025	....	1.44

*Size of sample increased from 39.7 mm. to 48 mm. in diameter.

NOTE.—Compare with above the results given by Sachs: *Ein Beitrag z. Kenntn. der Ernahrungsthatigkeit der Blaetter*, Arb. Würzb. **3**: 1. 1884, and Saposchnikoff: *Bildung und Wanderung der Kohlenhydrats in den Laubblättern*, Ber. Deutsch. Bot. Gesellsch. **8**: 233. 1890.

XXXIII. SOME MUSCINEAE OF THE NORTHERN BOUNDARY OF MINNESOTA, COLLECTED BY CONWAY MACMILLAN, DURING 1895.

J. M. HOLZINGER.

The mosses and liverworts enumerated below were collected between Saganaga and South lakes on the portage trails of the Dawson canoe route from Lake Superior to Winnipeg. The date of collection was between the 1st and the 10th of September. The mosses, except Sphagnaceae, have been determined by the author and the liverworts by Professor Lucien M. Underwood of Auburn, Alabama. The collection is remarkable for the large percentage of species in it not hitherto reported from Minnesota,* and includes one entirely new species of Fontinalis, named by M. Jules Cardot *in litt.* The author is under obligations to Dr. C. Warnstorf for determinations of the Sphagnaceae of the list; and to Dr. Rodney H. True of Madison, Wis., for determining *Dicranum palustre* DE LA PYL.

HEPATICAE.

1. **Conocephalum conicum** DUM.
   International boundary. No. 54.

2. **Chiloscyphus polyanthos** var. **rivularis** NEES.
   International boundary. No. 53.
   Not previously reported from Minnesota.

3. **Jungermannia barbata** SCHREB.
   International boundary. No. 56.
   Not previously reported from Minnesota.

4. **Jungermannia schraderi** MART.
   International boundary. No. 52.

*See my "Preliminary list of the mosses of Minnesota." Minn. Bot. Stud. **1**: 280 5 Mr. 1895.

5. **Radula complanata** Dum.
International boundary. No. 57.
Not previously reported from Minnesota.

6. **Ptilidium ciliare** Nees.
International boundary. No. 55.

MUSCI.

7. **Sphagnum cymbifolium** Ehr. var. **glaucescens** Warnst.
International boundary. No. 24.
Not previously reported from Minnesota.

8. **Sphagnum medium** Limpr.
International boundary. No. 26.
Not previously reported from Minnesota.

9. **Sphagnum recurvum** P. B. var. **parvifolium** (Sendt.) Warnst.
International boundary. No. 27.
Not previously reported from Minnesota.

10. **Sphagnum quinquefarium** (Braithw.) Warnst.
International boundary. No. 31.
Not previously reported from Minnesota.

11. **Sphagnum squarrosum** Pers.
International boundary. No. 45.

12. **Sphagnum wulfianum** Girg.
International boundary. No. 14.
Not previously reported from Minnesota.

13. **Dicranum bergeri** Bland.
International boundary. No. 28.

14. **Dicranum flagellare** Hedw.
International boundary. No. 32.

15. **Dicranum fuscescens** Turn.
International boundary. No. 49.

16. **Dicranum palustre** De la Pyl. "A form not uncommon in damp places," *R. H. True.*
International boundary. No. 33.
Not previously reported from Minnesota.

17. **Dicranum montanum** Hedw.
International boundary. No. 48.

18. **Dicranum scoparium** Hedw.
International boundary. No. 6

19. **Dicranum undulatum** Ehrh.
International boundary. No. 29.

20. **Ceratodon purpureus** Brid.
International boundary. No. 34

21. **Barbula ruralis** Hedw.
International boundary. No. 12.

22. **Grimmia apocarpa** Hedw.
International boundary. No. 22

23. **Hedwigia ciliata** Ehrh.
International boundary. No. 19.

24. **Orthotrichum obtusifolium** Schrad.
International boundary. No. 8.
Not previously reported from Minnesota.

25. **Tetraplodon angustatus** B. S.
International boundary. No. 50.
Not previously reported from Minnesota.

26. **Bartramia pomiformis** Hedw.
International boundary. No. 35.

27. **Bryum caespiticium** L.
International boundary. No. 10.

28. **Mnium cuspidatum** Hedw.
International boundary. No. 42.

29. **Mnium affine** Schw.
International boundary. No. 30.

30. **Aulacomnium palustre** Schw.
International boundary. Nos. 9, 37.

31. **Polytrichum commune** L.
International boundary. No. 23.

32. **Polytrichum juniperinum** Willd.
International boundary. No. 36.

33. **Fontinalis dichelymoides** Lindb.
International boundary. No. 38.
Not previously reported from Minnesota.

34. **Fontinalis macmillani** Card. *n. sp. in litt.*
International boundary. No. 38.
New to Minnesota.

35. **Neckera pennata** Hedw.
International boundary. No. 15.

36. **Pylaisia polyantha** B. S.
International boundary. No. 11.
Not previously reported from Minnesota.

37. **Climacium americanum** BRID.
International boundary. No. 39.

38. **Thuidium gracile** SCH.
International boundary. No. 1.

39. **Thuidium delicatulum** LINDB.
International boundary. No. 25.

40. **Thuidium abietinum** SCH.
International boundary. No. 2.

41. **Brachythecium salebrosum** SCH.
International boundary. No. 17.

42. **Brachythecium rutabulum** SCH.
International boundary. No. 13.

43. **Eurhynchium strigosum** SCH.
International boundary. No. 40.

44. **Rhynchostegium deplanatum** SCH.
International boundary. No. 3.
Not previously reported from Minnesota.

45. **Rhynchostegium serrulatum** L. & J.
International boundary. No. 18.

46. **Amblystegium serpens** SCH.
International boundary. No. 20.
Not previously reported from Minnesota.

47. **Hypnum fertile** SENDTN.
International boundary. No. 16.
Not previously reported from Minnesota.

48. **Hypnum subimponens** LESQ.
International boundary. Nos. 21, 41.
Not previously reported from Minnesota.

49. **Hypnum patientiae** LINDB.
International boundary. No. 46.

50. **Hypnum schreberi** WILLD.
International boundary. No. 7.

51. **Hylocomium splendens** SCH.
International boundary. No. 4.
Not previously reported from Minnesota.

52. **Hylocomium triquetrum** SCH.
International boundary Nos. 44, 47.

XXXIV. ADDITIONAL EXTENSIONS OF PLANT RANGES.

EDMUND P. SHELDON.

Stipa avenacea LINN. Sp. Pl. 78. 1753.

Not previously reported from Minnesota.

Collected near Poplar Island lake, Ramsey county, Minn. (*E. P. S.*, June, 1895).

Schedonnardus paniculatus (NUTT.) TRELEASE in Branner & Coville. Fl. Ark. 236. 1891.

This plant was reported in Upham's catalogue as having been collected in Mound township, Rock county, (*Leiberg*). It has been collected at Pipestone, Minn. (*Max Menzel*, June, 1895).

Hordeum nodosum LINN. Sp. Pl. ed. 2. 126. 1762.

This plant has been reported from Blue Earth county, Minn. (*Leiberg*). It has been collected at Pipestone, Minn. (*Max Menzel*, June, 1895).

Cyperus speciosus VAHL. Enum. 2: 364. 1806.

This plant has been questionably reported from Red Wing, Minn. (*Sandberg*). It has been collected at Glenwood, Minn. (*B. C. Taylor*, August, 1891); on shores of Big Stone lake near Browns Valley, Minn. (*E. P. S.*, Sept., 1892).

Scirpus lacustris LINN. var. **tenuiculmis** n. var.

An apparently well marked variety, differing from typical forms of the species in the slender, drooping, twice-umbellate inflorescence, the pedicels being usually singly terminated by the long-ovate, larger spikelets; by the slender, attenuated prolongation of the culm; and by the presence of

only three bristles, two on the edges of the achene where the convex and concave sides meet and a shorter one on the slightly concave side. (*See Plate XXX. f. 1.* culm; *f. 2.* inflorescence; *f 3.* achene *x. 33.*)

Collected in shallow water of lake Mora, Kanabec county, Minn. (*E. P. S.*, July, 1892); in ponds near Milaca, Minn. (*E. P. S.*, July, 1892); in shallow water at Battle lake, Otter Tail county, Minn. (*E. P. S.*, August, 1892); near Pipestone, Minn. (*Max Menzel*, July, 1895).

Scirpus pauciflora LIGHTF. Fl. Scot. 543. *t. 6.* 1777.

Not previously reported from Minnesota, but mentioned in Upham's catalogue as occurring in Canada and in the Red river valley.

Collected at Knife river, Minn. (*E. P. S.*, June, 1893).

Carex arctata BOOTT. var. **faxoni** BAILEY. Bot. Gaz. **13**: 87. 1888

Hitherto reported from Minnesota as occurring in the extreme northern part of the state (*Bailey*). Collected also near Two Harbors, Minn. (*E. P. S.*, July, 1893).

Carex assiniboinensis W. BOOTT. Bot. Gaz. **9**: 91. 1884.

Not previously reported from the United States.

Collected near Garrison, Crow Wing county, on the shores of Mille Lacs lake, Minn. (*E. P. S.*, June, 1892).

Carex deflexa HORNEM. Plantel. ed. 3. **1**: 938. 1821.

Not previously reported from Minnesota.

Collected near Highland, Lake county, Minn. (*E. P. S.*, June, 1893).

Carex pedunculata MUHL. Willd. Sp. Pl. **4**: 222. 1805.

Hitherto reported from Blue Earth county, Minn. (*Leiberg*). Collected also at Tower, Minn. (*E. P. S.*, June, 1893); and at Encampment, Lake county, Minn. (*E. P. S.*, June, 1893).

Carex teretiuscula GOODN. var. **ramosa** BOOTT. Ill. 145. 1867.

Not previously reported from Minnesota, but collected at Armstrong, Emmet county, Iowa (*Cratty*). Collected on dry ground in Ramsey county, Minn. (*E. P. S.*, May, 1895).

Carex umbellata SCHK. Riedgr. Nachtr. 75. *fig. 171.* 1806.

Not previously reported from Minnesota.[1]

Collected at Two Harbors, Minn. (*E. P. S.*, June, 1893).

Carex varia MUHL. Wahl. Kongl. Acad. Handl. II. **24**: 159. 1803.

Heretofore the only recorded occurrence of this species has been the questionable one of "Lapham, Minn."

Collected at Encampment, Lake county, Minn. (*E. P. S.*, June, 1893).

Allium reticulum DON. Mem. Wern. Soc. **6**: 36. 1826-31.

Not previously reported from Minnesota, although collected in the Red river valley in North Dakota (*Scott*).

Collected at Pipestone, Minn. (*Max Menzel*, May, 1895); and at Madison, Minn. (*Lycurgus R. Moyer*, May, 1894).

Salix cordata X candida.

An evident hybrid between these two species was found on the side of Buck hill, Dakota county, Minn. (*E. P. S.*, June, 1894).

This hybrid has the whitened pubescence on the under surface of the leaves and the pink-tinted styles of *Salix candida* FLUEGGE., but it grows to a height of three or four feet and has the general aspect and shape of leaves of the narrow-leaved forms of *Salix cordata* MUHL.

Polygonum exsertum SMALL. Bull. Torr. Club. **21**: 172. 1894.

Not previously reported from Minnesota.

Collected at St. Anthony Park, Minn. (*Dr. Otto Lugger*, August, 1893).

Polygonum littorale LINK. Schrad. Journ. Bot. **1**: 254. 1799.

Not previously reported from Minnesota.

Collected at St. Anthony Park, Minn. (*Dr. Otto Lugger*, August, 1893).

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(1) Reported also by J. M. Holzinger in "Determination of Plants Collected by Dr. J. H. Sandberg in Northern Minnesota During 1891," supra, p. 531.

Monolepis nuttalliana (R. & S.) GREENE. Fl. Fran. 168. 1891.

This plant has been previously reported from Minnesota as occurring at Browns Valley, Minn. (*E. P. S.*, Sept., 1893). It was also collected at Fort Snelling, Minn. (*A. P. Anderson*, May, 1893); and at Pipestone, Minn. (*Max Menzel*, August, 1895).

Gypsophila muralis LINN. Sp. Pl. 408. 1753.

Not previously reported from Minnesota.

This plant has become sparingly naturalized near St. Anthony Park, Minn. (*Dr. Otto Lugger*, Sept., 1892.)

Capnoides micranthum (ENGLM.) BRITT. Mem. Torr. Bot. Club. **5**: 166. 1894.

This species has been reported from Minnesota as growing in Martin county and the neighborhood of Sleepy Eye.

Collected also near Fort Snelling, Minn. (*E. P. S.*, June, 1895).

Lepidium apetalum WILLD. Sp. Pl. **3**: 439. 1800.

Lepidium intermedium A. GRAY. Pl. Wright. **2**:15. 1853.

All the Minnesota specimens heretofore referred to *Lepidium virginicum* LINN. belong to *L. apetalum* WILLD. (*Fide Dr. B. L. Robinson.*)

Sisymbrium altissimum LINN. Sp. Pl. 657. 1753.

The following is the record of the occurrence of this plant in North America: It was first reported in the Minneapolis Daily Tribune of Sept. 22, 1894, as having been found by me near Minneapolis. In the Bulletin of the Torrey Botanical Club of August, 1895, Mr. Lyster H. Dewey calls attention to its occurrence around Minneapolis, and also mentions that it has been collected on ballast ground at Philadelphia in 1878, and near Castle Mountain on the western boundary of Alberta in 1885. Mr. Dewey says of the plant that it "promises to be one of the most formidable tumbleweeds yet introduced in the United States." In the Bulletin of the Torrey Botanical Club of Nov., 1895, I made mention that the plant had spread so as to become a nuisance in the elevator districts of Minneapolis and St. Paul, and also noted that it had been found in several other localities in Hennepin, Ramsey and Dakota counties.

To this latter note, Dr. N. L. Britton, of Columbia college, added that he had found this plant at Port Arthur, Canada, in

September, 1889, and that it had been collected at Danville, Quebec, in 1894.

Specimens collected in Minnesota in the following localities have been deposited in the Herbarium of the University:

Near University avenue in S. E. Minneapolis, Minn. (*E. P. S.*, Sept., 1894); near Union and St. Anthony elevators, Minneapolis, Minn. (*E. P. S.*, June, 1895); Poplar Island lake, Ramsey county, Minn. (*E. P. S.*, June, 1895); near Peavey elevators between Cedar lake and St. Louis Park, Hennepin county, Minn. (*E. P. S.*, June, 1895); at Fort Snelling, Minn. (*E.P.S.*, June, 1895); near Mendota, Minn. (*E. P. S.*, June, 1895).

Brassica juncea (LINN.) COSSON. Bull. Soc. Bot. France **6**:609. 1859.

Not previously reported from Minnesota.

Collected near Poplar Island lake, Ramsey county, Minn. (*E. P. S.*, June, 1895).

Raphanus raphanistrum LINN. Sp. Pl. 669. 1753.

Not previously reported from Minnesota.

This plant, which is commonly called the "wild radish" is introduced in the market gardens around Minneapolis where it is likely to become a dangerous weed. Near Minneapolis, Minn. (*E. P. S.*, June, 1895).

Berteroa incana (LINN.) DC. Syst. Veg. **2**:291. 1821.

Not previously reported from Minnesota.

Collected on the bluffs near state fish hatchery, St. Paul, Minn. (*E .P. S.*, Sept., 1894).

Crataegus punctata JACQ. Hort. Vind. **1**:10. *t. 28.* 1770.

This species has been reported from Minnesota only as occurring near Center City, Chisago county.

Collected near Lakeville lake, Dakota county, Minn. (*E. P. S.*, May, 1894); and near Keegan's lake, Hennepin county, Minn. (*E .P. S.*, Sept., 1895).

Agrimonia mollis (T. & G.) BRITT. Bull. Torr. Bot. Club. **19**:221. 1892.

Not previously reported from Minnesota.

Collected near Goose lake, Carver county, Minn. (*C. A. Ballard*, July, 1891); Waconia, Minn. (*C. A. Ballard*, July, 1891); Cannon Falls, Minn. (*Dr. J. H. Sandberg*, July, 1881).

Agrimonia striata MICHX. Fl. Bor. Am. 1:278. 1803.

To this species is to be referred the Minnesota specimens heretofore called *Agrimonia eupatoria* LINN. The latter is a European plant which has larger fruit and denser, longer pubescence.

Sanguisorba officinalis LINN. Sp. Pl. 116. 1753.

Not previously reported from Minnesota.

Collected near St. Anthony Park, Minn. (*Dr. Otto Lugger*, Sept , 1893).

Astragalus ceramicus SHELD. Bull. Geol. Nat. Hist. Surv. Minn. No. 9. pt. 1. 19. 1894.

Not previously reported from Minnesota.

This western pulse has been introduced along the Belt Line railroad in Ramsey county, Minn. (*Francis Ramaley*, August, 1895).

Euphorbia dictyosperma FISCH. & MEYER. Ind. Sem. Hort. Petrop. 2:175. 1855.

Heretofore the only recorded occurrence of this species in Minnesota has been the collection at Montevideo (*L. R. Moyer*). Collected also at Pipestone, Minn. (*Max Menzel*, June, 1895).

Sanicula gregaria BICKNELL. Bull. Torr. Bot. Club. 22:354. 1895.

Not previously reported from Minnesota.

Collected near Milaca, Minn. (*E. P. S.*, July, 1892).

Limosella aquatica LINN. Sp. Pl. 631. 1753.

Not previously reported from Minnesota.

Collected near Pipestone, Minn. (*Max Menzel*, June, 1895).

Solidago ulmifolia MUHL. Willd. Sp. Pl. 3:2060. 1804.

The following are Minnesota localities in which this species has recently been found: Lake Lida, Otter Tail county, Minn. (*E. P. S.*, August, 1892); Zumbrota, Goodhue county, Minn. (*C. A. Ballard*, August, 1892); near Lanesboro, Fillmore county, Minn. (*Dr. J. C. Hvoslef*, August, 1895).

Aster lateriflorus (LINN.) BRITT. var. **grandis** PORTER. Mem. Torr. Bot. Club. **5**: 324. 1894.

Not previously reported from Minnesota.

Collected near Lanesboro, Fillmore county, Minn. (*Dr. J. C. Hvoslef*, August, 1895).

Aster prenanthoides MUHL. Willd. Sp. Pl. **3**: 2046. 1804.

Not previously reported from Minnesota, but recorded as occurring near Hesper, Iowa (*Mrs. Carter*).

Collected near Lanesboro, Fillmore county, Minn. (*Dr. J. C. Hvoslef*, August, 1895).

Aster tradescanti LINN. Sp. Pl. 876. 1753.

Not previously reported from Minnesota, although mentioned in Gray's Synoptical Flora of North America as occurring from Missouri and Illinois to the Saskatchewan.

Collected near Minnetonka, Minn. (*C. L. Herrick*, August, 1878).

Gaertneria acanthicarpa (HOOK.) BRITT. Mem. Torr. Bot. Club. **5**: 332. 1894.

Not previously reported from Minnesota.

Collected near New Brighton, Minn. (*J. M. Holzinger*, August, 1895).

Helianthus hirsutus RAF. Ann. Nat. 141. 1820.

Hitherto reported in Minnesota only from Idlewild, Lincoln county. Collected also near Lanesboro, Fillmore county, Minn (*Dr. J. C. Hvoslef*, July, 1895).

XXXV. NOTES ON THE MOSS FLORA OF MINNESOTA.

John M. Holzinger.

Until the mosses of Minnesota shall have been studied exhaustively, and the distribution of the species shall have been determined more exactly, it is proposed to furnish to the students of this group of Cryptogams an annual statement of the results of the year's work in the form of supplementary notes. During the past year the writer has collected in several localities. These collections are now worked up, together with some material collected in previous years. As a result, a number of additions to the Minnesota moss flora have been made, and numerous new stations have been established for the species already reported for the state in Minnesota Botanical Studies. **1**: 280. 5 Mr. 1895.

Note.—Except where otherwise stated, all plants are collected by the writer.

1. **Sphagnum cymbifolium** Ehr. var **glaucescens** forma **squarrosulum** Warnst. *C. Warnst. det.*
   New Brighton, near Minneapolis, August 4, 1895.
   Not previously reported from Minnesota.

2. **Sphagnum teres** Angstr. var. **squarrosulum** (Lesq.) Schimp. *C. Warnst. det.*
   Same station and date as the last.
   Not previously reported from Minnesota.

3. **Gymnostomum calcareum** Nees and Hornsh.
   Queen's Bluff, Oct. 26, 1895.

4. **Gymnostomum curvirostrum** Hedw.
   Minneapolis, August, 1895.

5. **Gymnostomum rupestre** Schw.
   Queen's Bluff, June 19, 1895.

6. **Weisia viridula** BRID.
Taylor's Falls, August 10, 1895; Minnesota river, August 17, 1895; Lamoille cave, Oct. 12, 1895.

7. **Dicranella varia** SCH.
Queen's Bluff, Oct. 26, 1895.

8. **Dicranum bergeri** BLAND.
New Brighton, August 4, 1895.

9. **Dicranum scoparium** HEDW.
Winona, March 30, 1895; Taylor's Falls, August 10, 1895.

10. **Dicranum undulatum** EHRH.
New Brighton, August 4, 1895.

11. **Conomitrium julianum** MONT.
Winona, on logs in the Mississippi river, Sept. 14, 1895.
Not previously reported from Minnesota.

12. **Leucobryum glaucum** SCH.
Taylor's Falls, August 10, 1895; Minnesota river, August 17, 1895.

13. **Ceratodon purpureus** BRID.
New Brighton, August 4, 1895.

14. **Seligeria pusilla** BRUCH & SCHIMP.
Winona bluffs, June 27, 1895.

15. **Didymodon cylindricus** BRUCH & SCHIMP.
Bear creek, Oct. 26, 1894; Winona bluffs, Sept., 1895.

16. **Desmatodon nervosus** BRUCH & SCHIMP.
Fort Snelling, August 17, 1895.
Not previously reported from Minnesota.

17. **Desmatodon obtusifolius** SCH.
Arcola, July 21, 1890.

18. **Barbula fragilis** BRUCH & SCHIMP.
Winona bluffs, April 11, 1895.

This is the same as No. 36, p. 285, *supra*. The credit of this correction belongs to M. Jules Cardot. Mrs. Britton disclaims the original determination. Recently I came into possession of European *Barbula fragilis*, and have taken pains to make close comparison, which has satisfied me that the plant is *Barbula fragilis* B. & S. Of course, the locality of No. 36 must be transferred to this species.

19. **Barbula mucronifolia** BRUCH & SCHIMP.
Minnesota river, August 17, 1895.

20. **Barbula unguiculata** HEDW.
Taylor's Falls, August 10, 1895.

21. **Grimmia pennsylvanica** SCHW.
Taylor's Falls, August 10, 1895.

This is what I reported at first as *Grimmia calyptrata.* After collecting the plant again in practically the same locality last season, in greater abundance, I re-examined it and detected my error.

22. **Orthotrichum pumilum** SW.
Minnesota river, August 17, 1895.

23. **Encalypta ciliata** HEDW.
Leech lake (*U. O. Cox,* July 9, 1895); Taylor's Falls August 10, 1895.

24. **Encalypta vulgaris** HEDW.
Taylor's Falls, August 10, 1895.
Not previously reported from Minnesota.

25. **Physcomitrella patens** SCH.

Mrs. E. G. Britton reports that Mrs. E. P. Sheldon communicated to her plants collected on the banks of the Minnesota river which proved to be this rare species.

26. **Funaria hygrometrica** HEDW.
Leech lake (*U. O. Cox,* July 5, 1895); New Brighton, August 4, 1895; Taylor's Falls, August 10, 1895; Queen's Bluff, Oct. 26, 1895.

27. **Bartramia pomiformis** HEDW.
Leech lake (*U. O. Cox,* July 10, 1895); Taylor's Falls August 10, 1895.

28. **Philonotis fontana** BRID.
Taylor's Falls, August 10, 1895.

29. **Aulacomnium palustre** SCHWAEGR.
New Brighton, August 4, 1895.

30. **Leptobryum pyriforme** SCH.
Leech lake (*U. O. Cox,* July 5, 1895); Taylor's Falls, July 10, 1890, and August 10, 1895.

31. **Webera albicans** SCH.
Lanesboro, August, 1894.

32. **Webera carnea** SCH.
Winona bluffs, August 29, 1895.

33. **Webera nutans** HEDW.
Leech lake (*U. O. Cox*, July 5, 1895).

34. **Bryum argenteum** L.
New Brighton, August 4, 1895.

35. **Bryum capillare** L.
Winona, May 11, 1895.
Not previously reported from Minnesota.

36. **Bryum ontariense** KINDB.
Taylor's Falls, August 10, 1895; Minnesota river, August 17, 1895.

37. **Bryum pendulum** SCH.
Minnesota river, August 17, 1895.

38. **Bryum pseudotriquetrum** SCHWAEGR.
Mississippi river bottoms, Winona, Jan. 11, 1896.

39. **Mnium hornum** L.

No. 83, in previous paper, is apparently *M. serratum*, young plants, the reported determination being an error. Intermixed are plants of *Mnium stellare*. No. 83 should therefore become *Mnium stellare*.

40. **Mnium serratum** BRID.
Lamoille, August, 1894.

41. **Mnium stellare** HEDW.
Winona bluffs, April 1, 1894; transferred from *Mnium hornum:* also March 23, 1895, and April 25, 1894; Bear creek, April 28, 1894.
Not previously reported from Minnesota

42. **Polytrichum commune** L.
Duluth (*S. C. White, Jr.*, March 25, 1895).

43. **Polytrichum formosum** HEDW.
New Brighton, August 4, 1895.
Not previously reported from Minnesota.

44. **Polytrichum juniperinum** WILLD.
Leech lake (*U. O. Cox*, July 5, 1895); Duluth (*S. C. White, Jr.*, Sept., 1895).

45. **Fontinalis hypnoides** HARTM.
Rendering factory tank, Minneapolis (*Josephine E. Tilden*, Sept., 1895).

46. **Fabronia octoblepharis** SCHW.
Taylor's Falls, on moist granite rocks, August 10, 1895.

47. **Thelia asprella** SULLIV.
Lake Harriett, near Minneapolis, August 16, 1895.

48. **Leskea polycarpa** EHRH.
Lamville, June 20, 1895; Minnesota river, August 17, 1895.

49. **Anomodon rostratus** SCH. A lax form.
Mankato, Nov. 16, 1894; Lamoille, October, 1895.

50. **Platygyrium repens** SCH.
Taylor's Falls, August 10, 1895; Queen's Bluff, Oct. 26, 1895.

51 **Pylaisia intricata** SCH.
Taylor's Falls, August 10, 1895; Minnesota river, August 17, 1895.

52. **Cylindrothecium cladorhizans** SCH.
Taylor's Falls, August 10, 1895.

53. **Thuidium abietinum** SCH.
Marine Mills, July 20, 1890; New Brighton, August 4, 1895.

54. **Thuidium gracile** SCH.
St. Croix Falls, Franconia, Osceola Mills, Marine Mills, July 2, 16, 17, 20, 1890; Lamoille, Oct. 30, 1893.

55. **Camptotherium nitens** SCH.
New Brighton, August 4, 1895.
Not previously reported from Minnesota.

56. **Brachythecium laetum** BRUCH & SCHIMP.
Osceola Mills, July 17, 1890.

57. **Brachythecium rivulare** BRUCH & SCHIMP.
Lamoille, Oct. 12, 1895.
Not previously reported from Minnesota.

58. **Eurhynchium sullivantii** LESQ. & JAMES.
Lanesboro, August, 1894; Queen's Bluff, Oct. 26, 1895.
Not previously reported from Minnesota.

59. **Rhynchostegium serrulatum** HEDW.
Minnesota City, March 17, 1894; Lake Harriett, August 16, 1895.

60. **Plagiothecium sylvaticum** BRUCH & SCHIMP.
Taylor's Falls, August 10, 1895; Winona, June, 1894.
Not previously reported from Minnesota.

61. **Amblystegium adnatum** LESQ. & JAMES.
St. Croix Falls, July 12, 1890; Trempealeau Mt., Nov. 11, 1893.

62. **Amblystegium irriguum** (HOOK. & WILS.) LESQ. & JAMES.
Catholic Cemetery, Oct. 6, 1894.
Not previously reported from Minnesota.

63. **Amblystegium kochii** SCH.
Oscola Mills, St. Croix river, July 17, 1890.
Not previously reported from Minnesota.

64. **Amblystegium minutissimum** LESQ. & JAMES.
Winona bluffs, May 6, 1893.
Not previously reported from Minnesota.

65. **Amblystegium noterophilum** SULL. & LESQ.
Bear Creek, May, 1894.

66. **Amblystegium serpens** SCH.
Franconia, July 16, 1890.

67. **Hypnum aduncum** HEDW.
Marshland, Wis., August 18, 1890; edge of lake Winona, Oct. 1, 1894; Lamoille, August 24, 1894.
Not previously reported from Minnesota.

68. **Hypnum chrysophyllum** BRID.
Winona, May, June, August, 1894; Lanesboro, August, 1894; Franconia, July 16, 1890.

69. **Hypnum filicinum** L.
Mankato, Nov. 16, 1894; Lamoille, June 20, 1895.
Not previously reported from Minnesota.

70. **Hypnum fluitans** L.
Lake Winona, Dec. 20, 1894.
Not previously reported from Minnesota.

71. **Hypnum haldanianum** GREV.
Marine Mills, July 20, 1890; Laird's mill, March 31, 1894; lake Harriet, August 16, 1895.

72. **Hypnum hispidulum** BRID.
Lamville, June 17, 1890; Fountain City, Wis., August, 1890; Winona, May, 1894; Lanesboro, July 15, 1894.

73. **Hypnum patientiae** LINDB.
Arcola, July 21, 1890; Lamoille, June 20, 1895.

74. **Hypnum schreberi** WILLD.
Winona bluffs, May 5, 1894; Taylor's Falls, August 10, 1895.

75. **Hypnum vaucheri** SCHIMP.
Winona bluffs, Dec., 1894.
Not previously reported from Minnesota.

76. **Hylocomium rugosum** DE NOT.
Taylor's Falls, August 10, 1895.

77. **Hylocomium triquetrum** SCH.
Marine Mills, July 20, 1890; Leech lake (*U. O. Cox*, July 5, 1895).

XXXVI. LIST OF FRESH-WATER ALGAE COLLECTED IN MINNESOTA DURING 1895.

JOSEPHINE E. TILDEN.

Of the appended list, which is continued from page 237 of this publication, the greater number of the plants were sent into the laboratory by outside collectors. It is interesting to note the occurrence of *Aphanizomenon flos aquae* and *Clathrocystis aeruginosa* in different parts of the state as a probable result of the prolonged drouth experienced during the past summer. These plants produce the effect known as "wasser-blüthe" or the "breaking of the meres." The former plant was also collected by Professor J. C. Arthur, at Waterville, Minnesota, in 1882.

Twenty-four of the species here given are new to the state.

202. **Chara fragilis** DESV. in Loiseleur Nat. Fl. Fr. 157. 1810.
Lake Calhoun, Hennepin county. August 4, 1895.

203. **Hormiscia subtilis** (KG.) DE-TONI, var. **subtilissima** RABENH. Fl. Eur. Algar. **3**: 365. 1868.
In water brought in from a well and left standing in a corked bottle all winter, Mankato. February 29, 1896. Coll. *U. O. Cox.*

204. **Chaetophora pisiformis** (ROTH) AG. Syst. Alg. 27. 1824.
In spring, Long lake, Hennepin county. September 5, 1895. Coll. *B. T. Shaver* and *J. E. T.*

205. **Stigeoclonium protensum** (DILLW.) KG. var. **subspinosum** (KG.) RABENH. Krypt. Flor. v. Sachs. 267. 1863.
In tub, Long lake, Hennepin county. September 5, 1895. Coll. *B. T. Shaver* and *J. E. T.*

206. **Stigeoclonium flagelliferum** KG. Phyc. Germ. 198. 1845.
In fountain, Kenwood, Minneapolis. August 3, 1895.

207. **Stigeoclonium amoenum** KG. Spec. Alg. 355. 1849.
Lake of the Woods. July 20, 1894. Coll. *Conway MacMillan.*

208. **Microspora vulgaris** RABENH. Krypt. Flor. v. Sachs. 245. 1863.
In spring, J. H. R. Works, Red Wing. April 1, 1895. Coll. *A. A. Butler*

209. **Cladophora callicoma** AG. Phyc. Gener. 257. 1843.
On stones, Mississippi river, Winona. September 15, 1894. Coll. *J. M. Holzinger.*

210. **Rhaphidium braunii** NAEG. in Kg. Spec. Alg. 891. 1849.
Bethania Springs, Osceola, Wis. August 31, 1895.

211. **Apiocystis brauniana** NAEG. in Kg. Spec. Alg. 208. 1849.
On sides of zinc sorghum tub containing rainwater, Long lake, Hennepin county. September 3, 1895. Coll. *B. T. Shaver* and *J. E. T.*

212. **Protococcus viridis** AG. Syst. Alg. 13. 1824.
On tree trunk five feet from ground, on bank of Mississippi river, Minneapolis. September 17, 1895.

213. **Mougeotia genuflexa** (DILLW.) AG. Syst. Alg. 83. 1824.
St. Peter. October 4, 1895. Coll. *Henry Tilden.*

214. **Zygnema stellinum** (VAUCH.) AG. Syst. Alg. 77. 1824.
State fish hatcheries, St. Paul. August 15, 1895.

215. **Spirogyra porticalis** (MUELL.) CLEVE. Svensk. 22. *pl. 5.* 1868.
R. R. "L 197," Red Wing. April 1, 1895. Coll. *A. A. Butler.*

216. **Spirogyra jugalis** (DILLW.) KG. Spec. Alg. 442. 1849.
In pond, Zumbrota. July, 1895. Coll. *C. A. Ballard.*

217. **Spirogyra majuscula** KG. Spec. Alg. 441. 1849.
Long lake. September 5, 1895. Coll. *B. T. Shaver* and *J. E. T.*

218. **Spirogyra calospora** CLEVE. Svensk. Zygnem. 26. *pl. 8. f. 1-5.* 1868.
Red Wing. June 8, 1895. Coll. *A. A. Butler.*

219. **Desmidium swartzii** AG. Syst. Alg. 9. 1824.
Pond, St. Peter. October 4, 1895. Coll. *Henry Tilden.*

220. **Closterium acerosum** (SCHRANK) EHRENB. Abh. Berl. Akad. 1831.
Sleepy Eye lake. May 17, 1895. Coll. *A. A. Butler.*

221. **Cosmarium laeve** RABENH. Fl. Eur. Algar. **3**:161. 1868.
Sleepy Eye lake. May 17, 1895. Coll. *A. A. Butler.*

222. **Plectonema wollei** FARLOW. In Bull. Bussey Inst. 77. 1875.
Long lake, Hennepin county. September 5, 1895. Coll. *B. T. Shaver* and *J. E. T.*

223. **Phormidium favosum** (BORY) GOMONT. Ann. Sci. Nat. Bot. **16**: 180. 1892.
In trough, Osceola, Wis. August 30, 1895.
In tub, Long Lake, Hennepin county. September 5, 1895. Coll. *B. T. Shaver* and *J. E. T.*

224. **Phormidium incrustatum** (NAEG.) GOMONT. Bull. Soc. Bot. de France. **36**: Cliv. 1889.
Osceola, Wis. August 28, 1895.

225. **Phormidium ambiguum** GOMONT. Ann. Sci. Nat. Bot. **16**: 178. 1892.
State fish hatcheries, St. Paul. September 15, 1895.

226. **Aphanizomenon flos aquae** RALFS. Ann. Mag. Nat. Hist. **5**: 340. 1850.
Lake of the Woods. July 20, 1894. Coll. *Conway MacMillan.*
Lake Minnetonka. 1895. Coll. *A. L. Crocker.*
Long lake, Hennepin county. September 5, 1895. Coll. *B. T. Shaver* and *J. E. T.*

227. **Chamaesiphon incrustans** GRUN. In Rabenhorst's Fl. Eur. Algar. **2**: 149. 1865.
In tank in botanical laboratory, Minneapolis. February 15, 1896.

228. **Dichothrix orsiniana** (Kg.) BORNET and FLAHAULT. Am. Sci. Nat. Bot. VII. **3**: 376. 1886.
Kenwood, Minneapolis. August 3, 1895.

229. **Clathrocystis aeruginosa** HENFR. Micr. Journ. 53. 1856.
Long lake, Hennepin county. September 5, 1895. Coll. *B. T. Shaver* and *J. E. T.*
Como park, St. Paul. August 10, 1895.

230. **Gomphosphaeria aponina** Kg. Phyc. Tab. 1: *pl. 31. f. 3.* 1845–69.
In tank in Botanical laboratory, Minneapolis. October 8, 1895.

231. **Cymbella gastroides** Kg. Bacill. 73. *pl. 6. f. 4. b.* 1844.
Pond, St. Peter. October 4, 1895. Coll. *Henry Tilden.*

232. **Cymbella cymbiformis** (Kg.) Bréb. Alg. Falaise. 49. *pl.* 7. 1855.
St. Croix river, Osceola, Wis. August 26, 1895.

233. **Gomphonema olivaceum** (Lyngb.) Kg. Bacill. 85. *pl. 7. f. 13.* 1844.
In Minnesota river. April, 1895. Coll. *Conway MacMillan, D. T. MacDougal, A. Foss.*

234. **Cymatopleura solea** (Bréb.) W. Sm. in Ann. Nat. Hist. 12. *pl. 3. f. 9.* 1851.
Chantaska creek, St. Peter. October 4, 1895. Coll. *Henry Tilden.*

235. **Synedra pulchella** (Ralfs) Kg. Bacill. 68. *pl. 29. f. 37.* 1844.
Spring, J. H. R. Works, Red Wing. April 1, 1895. Coll. *A. A. Butler.*

236. **Synedra ulna** (Nitzsch) Ehr. Inf 211. *pl. 17. f. 1.* 1838.
Railway ditches, Osceola, Wis. August 28, 1895.

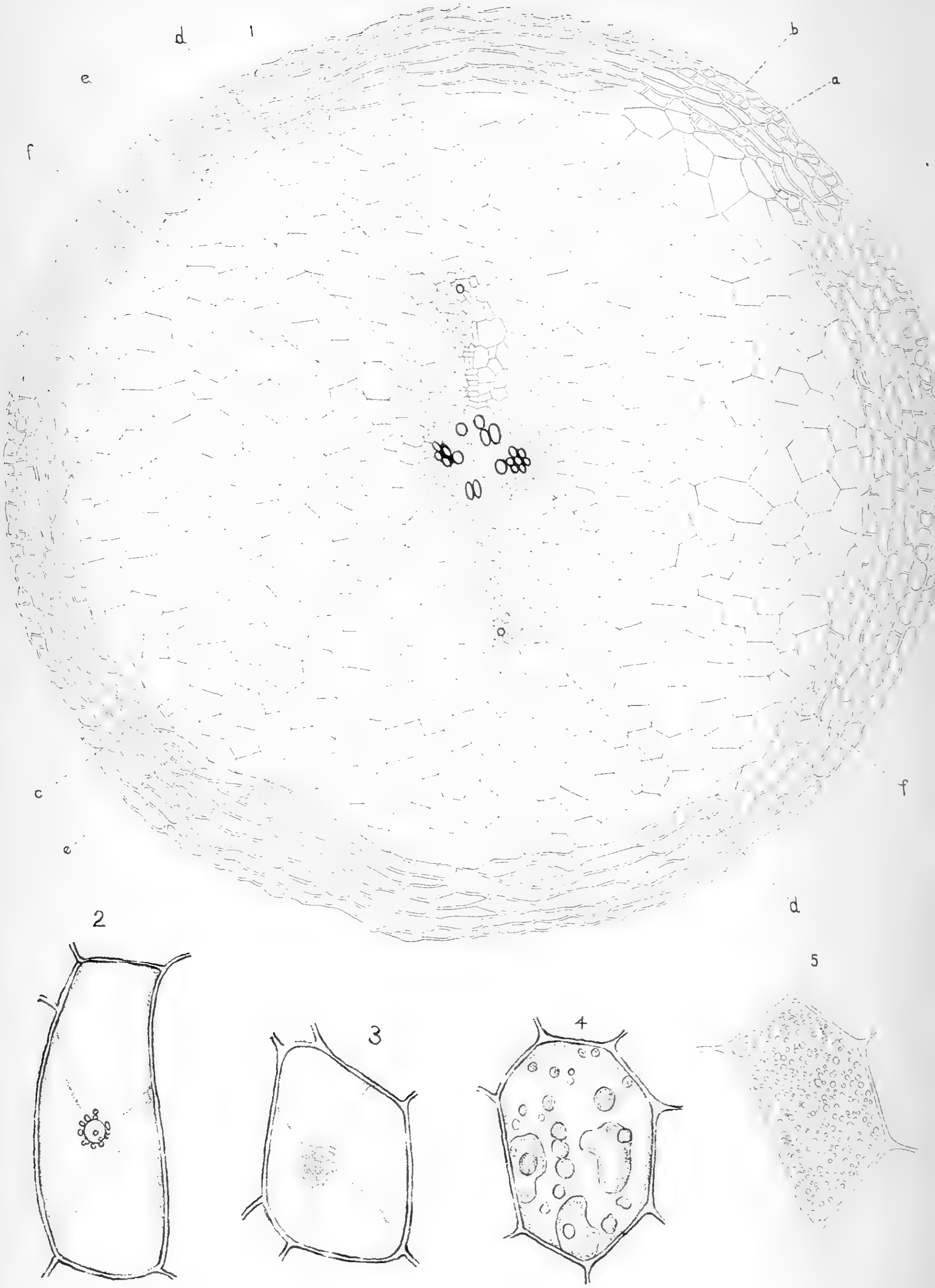
237. **Fragilaria virescens** Ralfs, var. **producta** Lagerst. Diat. Spetsb. 15. *pl. 1. f. 1.* 1873.
In a tank, Long lake, Hennepin county. September 4, 1895. Coll. *B. T. Shaver* and *J. E. T.*

238. **Cystopleura gibba** (Ehr.) De-Toni. Syll. Alg. 2: pt. 780. 1892.
St. Peter. October 4, 1895. Coll. *Henry Tilden.*

239. **Lysigonium varians** (Ag.) De. Toni. Alg. Abyss. 1891.
Railroad ditches. Osceola, Wis. August 28, 1895.

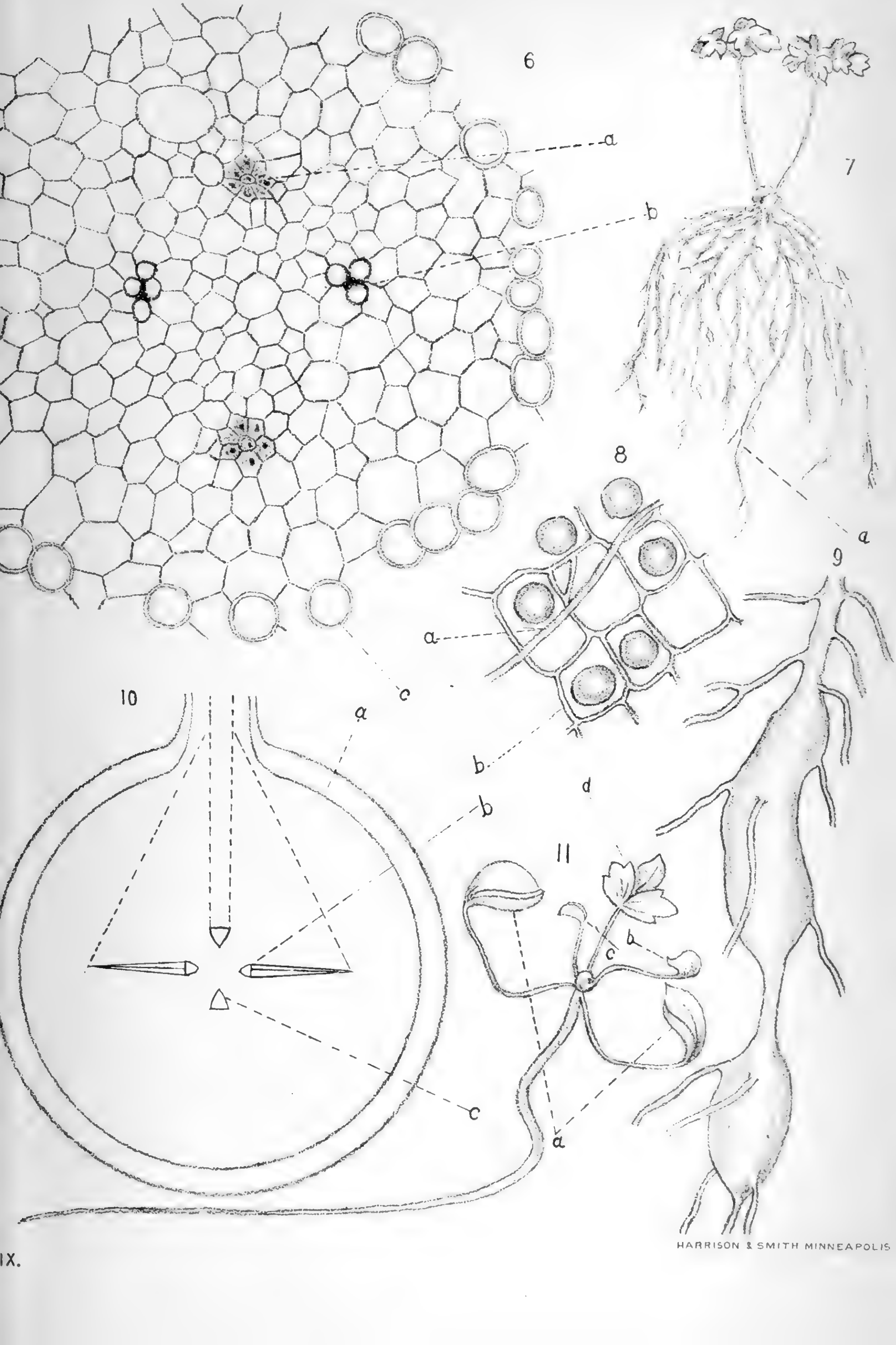
PLATE XXVIII.

PLATE XXVIII.



J. E. TILDEN, del.

PLATE



HARRISON & SMITH MINNEAPOLIS

IX.

PLATE XXX.

XXXVII. A CONTRIBUTION TO THE LIFE HISTORY OF PILINIA DILUTA WOOD AND STIGEOCLONIUM FLAGELLIFERUM KG.

JOSEPHINE E. TILDEN.

While engaged in studying some species of lime-secreting algae, the following paragraph in Dr. Wood's (I) "History of the Fresh-Water Algae of North America," came under my notice: "Near Bellefonte, Centre county, Pennsylvania, there issues from the limestone rocks the largest spring I have ever seen, giving rise to a creek-like torrent, which supplies the city with water, and passes on scarcely diminished in volume. In this spring grows the curious alga under consideration, forming a somewhat lubricous and stony stratum on the stones and rocks in the basin. This stratum is of a grayish-green color, and is quite friable, breaking in the direction of the filaments with the greatest possible readiness. When placed under the microscope it is seen to be composed of filaments whose course is a direct one from the under to the upper surface. They are apparently rigid, preserving their courses, and not being intermatted. They are composed of cylindrical, confervoid cells, and are dichotomously branched, and yet when viewed as a whole the filament and its branches form a sort of fasciculus. The basal cell or cells appear to be globular. When I collected this plant I was forced by circumstances to put the specimens in carbolic-acid water for future study, and, therefore, I have had no opportunity of studying their method of reproduction. I am not altogether satisfied in referring this plant to the Pilinia, and yet all the most important of the characters given by Rabenhorst are preserved by it. It certainly, however, differs very greatly from P. rimosa Ktz."

Dr. Wood names the plant Pilinia diluta. His description of it will be given later.

This promised interesting matter for investigation, and though it seemed improbable that a plant which grew in a spot more than twenty years ago should have been able to maintain

its foothold until the present time, a letter was sent to the postmaster at Bellefonte, Mr. David F. Fortney, asking his aid in procuring some specimens. He replied that the spring was thoroughly cleaned at intervals and for that reason it might not be possible to find the plant, but that if it existed, it should be sent me. Upon his recommendation I then communicated with Miss Ella Levy, the teacher of Botany in the Bellefonte High School, explaining as well as possible the probable nature and appearance of the growth. It was feared that even if it were still in existence there would be a difficulty in recognizing the Pilinia among the many other algal forms which would naturally be its neighbors, since from the frequency of the cleaning process, it could scarcely have time to form the crust which would have distinguished it.

Miss Levy forwarded two pebbles taken from the bed of the spring, without very much hope that the Pilinia would be found on them. However, they proved to be covered with an algal growth unmistakably identical with that described by Dr. Wood. The question of whether the plant was a Pilinia or not called for further investigation. Later an abundance of the material was secured.

Some of these pebbles were kept in tanks during a period of two months, the water being changed frequently. By the end of that time, the plant itself had solved the problem of its identity in the most effectual manner possible by simply transforming itself into a common Stigeoclonium. When this fact was proved, an effort was made to look up the literature concerning this genus. Finding that, though of long standing, it had not been made the subject of much research, it was thought that it might be well in giving the results of these investigations upon the Pilinia stage, to include whatever facts had come under observation relating to the Stigeoclonium and Palmella stages. The microscopic structure and development of the plant will therefore be considered under three heads: 1. Pilinia stage. 2. Stigeoclonium stage. 3. Palmella stage. Since in the first named stage there is certainly a distinct adherence to Pilinia characteristics, as furnished by Kuetzing, a brief history of this genus is given with the idea of showing the possibility of truth in the theory offered by Wille (I) viz.: That the genus Pilinia is made up of species which represent stages of other algae. It is not so easy to accept his further statement that these are of the Phycochromaceae.

History of the genus Pilinia. Upon a comparison of the literature the greatest diversity of opinion concerning the nature of the genus Pilinia, was found to prevail, and, indeed, according to some authors no such genus should be maintained.

The genus was created in 1843 by Kuetzing (I), and in it he placed the species P. rimosa. His specimens were gathered near Cuxhaven, in July, 1839.

The earliest description at hand is that of Rabenhorst (I), published in 1868. "Pilinia Ktz. (1843): Fila articulata erecta, simplicia vel parce ramosa, basi callosa quasi radicata affixa, in stratum crustaceum tenue spongiosum olivascens coalescentia. Propagatio ignota.

"P. rimosa Ktz. (Phycol. gener. p. 273,) P. lignicola, crustacea, olivaceo-viridis, initio porosa, postea rimosa, mucosa; filis ramisque fasciculatis; articulis diametro (0.00029–0.00038") aequalibus vel duplo longioribus. v. v.

"Hab. in postibus lignisque aestu maris continuo irroratis insulae Suelt, Norderney (L. R.), prope Cuxhaven, ubi frustra quaesivi, detexit 1839 mense Jolio cl. Kuetzing."

Dr. Wood (I) was the next contributor to the genus. He, rather hesitatingly, however, offers a new species. The description is as follows:

"GENUS PILINIA KTZ. Filaments articulate, erect, dichotomously branched, fixed by the base, aggregated into a somewhat spongy fragile crustaceous stratum. Method of propagation unknown.

Pilinia diluta WOOD (sp. nov.) Growing on stones and rocks, forming a grayish-green stratum; filaments and branches fasciculate, with the apices obtuse; joints 1½–3½ times longer than broad. Diam. Max. 0.0004". Hab. In a large fountain, near Bellefonte, Centre county, Pennsylvania; Wood."

No more attention was paid to the genus until 1888, when De-Toni (I) in comparing the genera of the Trentepohliaceae, notes that the genus Pilinia Kuetz. seems to him identical with the genus Acroblaste Reinsch (*Reinsch* I). A year later he makes a more extended exposition of this belief (*De-Toni* II) and quotes Hansgirg (II) as agreeing with him on this point and also referring Chaetophora pellicula Kjellm. (*Kjellman* I) to the same genus. Accordingly in his *Sylloge Algarum* (*De-Toni* III) he places both Acroblaste and Chaetophora pellicula under Pilinia rimosa.

Wille (I) holds a different view, he retains Acroblaste as an authentic genus, but removes Pilinia to the "unsichere gat-

tungen" on the ground that upon investigation of the original specimens they are proved to be young stages of various algae, but particularly of the Phycochromaceae.

In a later work Hansgirg (IV) quotes his own remarks concerning Pilinia from his paper in *Flora* and mentions a new species of Pilinia (P. minor) as described by himself (III). The same species is given as new in a review of an article by the same author (V). As access cannot be had to these two descriptions, further discussion of them will be omitted.

Description of the Bellefonte Spring. This spring is famous both for its size and the purity of its water. It is sixty-five feet in width, eighty-five feet in length, and eight feet in depth. Year after year, without variation, it discharges 14,600 gallons of water per minute. Not only does it supply the town of Bellefonte with water, but its power is used to pump water up a hill to a distributing reservoir, and then the quantity going to waste is large, "making a stream like a mill tail." Its temperature remains nearly unchanged during the different seasons, being in winter 51° F. and in summer 52° F.

Through the kindness of Mr. Fortney, the following extract from the report of an analysis of the water was obtained:

Total solid residue	152.3	parts per million.
Of which was lost in ignition	36.3	"
Leaving freed residue	116.0	"
Degree of hardness	11.	"
Poisonous metals	Absent.	
Color	None.	
Odor	None.	
Free ammonia	0.028	parts per million
Albuminoid ammonia	0.044	"
Oxygen required for moist combustion	0.7	"
Chlorine	7.84	"
Nitrogen as nitrates and nitrites	Absent.	

The spring is fed by an underground stream pouring in at the south-east corner and passing out at the north-west corner. There is no perceptible current in the water except at the immediate outlet. These conditions have their effect upon the nature of the algal growth in different parts of the basin. Pebbles taken from the running water in the north-west corner of the basin were covered with species of Oscillatoria with not a trace of Pilinia among them. Around the inlet there is no vegetation of any kind. A species of Chara grows on the bottom. The pebbles bearing the

Pilinia thalli were taken from the bottom of the spring with a long handled rake.

Miss Levy informs me that at the present time the spring is surrounded by a walk of crushed limestone and the stone extends down into the basin a foot or more. There are now no rocks around the edge and but few in the basin.

Many similar springs occur in the vicinity, one as large and others much smaller. The Pilinia occurred on pebbles found in some of these. As far as I can judge it only grows in quiet water, and in no instance was it discovered on wood.

Microscopic Structure of Plant:—The first installment of pebbles was received from Miss Levy on January 24th, 1896. They had been taken from the bed of the spring three days previous and packed in damp cotton together with some of the Chara found growing in the spring. Upon being placed in water they were seen to be covered on the top and sides with a slippery coating of algae, apparently healthy in color—a peculiar dark, lustrous, velvety green. The pebbles were pronounced by Mr. Elftman of the geological department of the University of Minnesota, to be a silicious dolomite.

The thalli of the algae consisted of circular, flat masses, from 1 to 1.5 mm. in diameter and were solitary, or confluent, or piled upon each other. On the top and more exposed parts of pebble "1" (Pl. XXXI, Fig. 1) the algal layer was of the green color described above and was mucilaginous to the touch. On the sheltered surface however, the thalli were of a bluish-gray color, decidedly calcareous in aspect and when rubbed with the finger felt "sandy". The thalli were so numerous that they formed an almost continuous stratum. This pebble was placed in a glass tank, frequently replenished with fresh water, but the plant survived only a few days. At the end of three days the coating had changed to an olive-green color. On pebble "2" as can be readily observed in the photograph (Pl. XXXI, Fig. 2), the discs are solitary and scattered. This was allowed to dry, while yet in good condition, for herbarium material.

An attempt to procure a second supply of Pilinia, brought only Oscillatoria material. The pebbles were collected from the northwest corner of the spring where the outflow caused a current.

On April 3rd, Miss Levy again collected and sent material. Two pebbles, "3" and "4", procured from the bottom of the main spring and four pebbles and a couple of bits of glass

taken from various springs in the immediate neighborhood of the large one were received four days later.

Pebble "3" was covered on the upper parts with solitary, irregularly shaped mounds, 2 mm. or more in diameter. Sometimes these were confluent. Each thallus was capped by a light-colored grain, .5 to 1 mm. in diameter, which produced an odd effect. The "caps" when observed with low power showed a compact structure, not flaky or uneven like the fragments of lime which are scattered through the interior of the thallus. They were perforated with numerous tubes which the filaments and branches of the plant had occupied.

Pebble "4" possessed a dark green, mucilaginous coating which was not made up of solitary thalli but was continuous. But for the color, it had all the appearance of an Oscillatoria. It had none of the "caps" described above, but was characterized by very fine, sand-like grains which were scattered throughout the substance and could be discerned with the naked eye. The other pebbles and bits of glass were covered with a continuous layer of cells, connected into extensive plates.

MICROSCOPIC STRUCTURE.

1. Pilinia Stage: The microscopical appearance of the alga may perhaps best be understood by describing it as a Coleochaete-like plate of cells giving rise to upright Chaetophora-like filaments. The thallus resulting from this manner of growth takes the form of a flat-topped mound or a thickened disc, and while in general appearance it resembles the ordinary Chaetophora type, it is thus seen to differ in internal structure from the latter which is made up of filaments radiating from a common center. Microscopic investigation is necessarily confined to fragments or at least to young thalli, since the cover glass breaks and crushes the mass out of shape.

The usual appearance under the cover glass consists of detached rows of plate cells with the filaments standing out at right angles (Pl. XXXII, fig. 1). This figure will be seen to be quite similar in its vegetative appearance to those of Acroblaste represented by Reinsch (I) Pl. III. fig. 1, 2, 3. The resemblance goes no further, however, since the reproductive organ of Acroblaste is confined to the end of the filament and is peculiar in structure and behavior. The measurement of the filaments and microzoospores of Acroblaste also agrees with that of Pilinia in the same portions.

Rabenhorst (I) gives a figure of Pilinia rimosa, which though it does not afford a very definite idea of the plant corresponds in essential points to the Pilinia stage of Stigeo clonium. It shows basal cells and short upright filaments which branch in a simple manner towards the apex.

The plate cells, or basal cells of the filament, originally spherical in form, like all algal cells which unite in plates, soon become angular in outline. Their diameter is in the neighborhood of 12 mic. When the plant is in a healthy condition they are nearly filled with a vegetative green coloring matter. Each one contains a large and distinct pyrenoid sometimes occupying as much as one-third the diameter of the cell. Near this there is a clear, colorless space, depending it would seem for its size and distinctness, upon the age and condition of the cell. It is scarcely noticeable in young plants but becomes larger and more apparent as the cell matures. In general several granules of different sizes are present.

A somewhat interesting point is the occurrence of etiolated cells in close proximity to cells in apparently flourishing condition. In the material taken from pebble "3," after it had existed ten days out of its natural abode, the basal cells in small fragments of the plant, were sometimes all colorless, sometimes all chlorophyll-bearing, and sometimes the two states occurred together. The upright filaments growing from these frequently had their lower cells perfectly colorless, while the upper ones were chlorophyll-bearing in the usual manner. Very often a row of basal cells was entirely colorless, while all the cells in the filaments arising from them were chlorophyll bearing and appeared healthy in all respects.

The material when taken directly from the spring has always shown the Pilinia state. In the upright filaments of this the cells are long and cylindrical The branching is sometimes dichotomous like that of a Chætophora (Pl. XXXII, fig. 2 and 3), or in other cases the branches given off are few and simple like those of Stigeoclonium (Pl. XXXII, fig. 1). Also the filaments may attain quite a height without branching at all or they may be profusely branched throughout. The lower cells are from 5–7.5 mic. in width, with a length of 2½ to 3 times as much. The upper cells are 7.5 mic. in diameter and 2½ times as long.

In the lower cells of the filament a protoplasmic mass containing the chlorophyll grains and starch granules occupies approximately the central third of the cell (Pl. XXXII, fig. 3). The two ends are colorless and apparently empty. The propor-

tion of green cell contents becomes gradually greater in each successive cell as the apex is approached, the end cells being generally quite filled (Pl. XXXII, fig. 2). The chlorophores consist of flat, circular plates (Pl. XXXII, figs. 7, 8). The pyrenoids are prominent and lie embedded in the protoplasmic matter. They often measure from 2 to 3 mic. in diameter.

It is a fact that no fresh material has shown bristles. The apices of the branches are subulate with no evidence at all of hyaline chaetophorous prolongations (Pl. XXXII, figs. 1, 2, 3). After the first few days, however, these make their appearance in the greatest abundance. On the tenth day after the first lot of material was taken from the spring, the bristles were first observed. They grew from cells near the basal cells, that is, from upright filaments containing only two to four cells (Pl. XXXII, fig. 4). They were also developed directly from the basal cells (Pl. XXXII, fig. 5). Ordinary vegetative filaments grew from the adjoining basal cells. The bristle shown in fig. 5 is 160 mic. in length.

The branches in general and sometimes the branchlets of the filaments are terminated by very long and robust hair-like growths which are multicellular in structure. It is usual for the first colorless cell at the end of a filament to taper abruptly from the width of the ordinary vegetative cell to about one-half as much (Pl. XXXII. fig. 6). The remainder of the cells become more gradually attenuated until the apex is reached where a somewhat bulbous knob is formed.

A bristle 175 mic. in length had a terminating cell 25 mic. long with a diameter of 2 mic. The longest cell which is near the middle was 45 mic. in length. The diameter of the lowest cell was 4 mic. In another case the length was 350 mic. and includes five cells, three of which are very long, while the two next the vegetative cells are very much shorter. The end cell was 110 mic. in length, the next two averaged 85 mic. apiece, while the short ones were each 35 mic. in length. A bristle measuring 500 mic. from base to tip terminated a branch of vegetative cells. Another displayed a length of 650 mic. Near the base it had a diameter of 7.5 mic., while at the tip it was 5 mic. across. It is more common for them to be extremely fine at their extremities. The longest example noted was 1000 mic. from the last vegetative cell to the tip of the filament.

From the first the contents of some of the apical cells were found to be in process of division. They were divided into

four nearly cubical portions (Pl. XXXII, fig. 1). In a day or two lower cells showed evidence of a similar division and a swelling of these cells was also apparent (fig. 7). This behavior proved to be preliminary to the production of megazoospores. It is thus seen that the vegetative cell in becoming a gonidangium practically does not change in form.

The gonidangia develop from terminal cells or from any of the upper cells of the main filaments or the branches. In rare cases they were seen in direct proximity to the basal cell. Instances occurred in which a short, one-celled reproductive branch sprang off at right angles to the filament. Sometimes it rose from the upper portion of the cell following the ordinary method of branching among the Chaetophoraceae (Pl. XXXII, fig. 8), but as often it was developed from the base of the cell (Pl. XXXII, fig. 9).

As the spores mature and escape they are found to number from one to four in a cell (Pl. XXXII, figs. 10, 11, 13). Cells in the upper branches give rise to two or four zoospores of exactly the same size and appearance. All the other cells in the vicinity of a reproductive cell may be vegetative, some even in the act of sending off branches (Pl. XXXII, fig. 13), or several neighboring cells may also be reproductive (Pl. XXXII, figs. 7, 12, 14).

Sometimes the gonidangium is large and roomy (Pl. XXXII, figs. 14, 15), at other times the spores are crowded together like those of Ulothrix zonata (Pl. XXXII, figs. 12, 16). Taking an example of the first sort (Pl. XXXII, fig. 15), the cell is 16 mic. in length, 4.8 mic. in diameter at the end walls, and 9.6 mic. across the swollen middle portion. The two spores, 6.5 mic. in diameter, lie easily side by side. An example showing the contrary condition (Pl. XXXII, fig. 16) is a cell 11.2 mic. in diameter and 8 mic. in length. The spores like the last are 6.5 mic. in diameter and they so completely fill the mother cell that the walls are considerably distended. A swollen cell containing but one spore is shown (Pl. XXXII, fig. 10) in the end of a branch all the cells of which are reproductive.

For some time before escaping, the spores appear perfectly mature. The shape is distinct, either globose or oval according as the end or side is presented to view. The pigment spot is relatively large and bright. A branch of reproductive cells, the zoospores of which are near maturity and all at the same stage, shows the eye-spots very distinctly (Pl. XXXII, fig. 12). The spores as viewed within the cell appear to have a distinctly

hyaline portion, in many cases, at least, there are visible darker and lighter areas.

A group of basal cells was observed from which were given off directly reproductive cells. Three of these filaments contained the swollen cells. In the fourth filament which contained three cells, the twelve spores were just ready to escape. The cell-walls enclosing them were very faintly visible, as a mere outline. The spores as observed were in active movement, sliding upon each other with a quick, jerky motion like that of the bell animalcule as it withdraws itself upon contact with any object. They moved in a direction at right angles to the filament. Two lying side by side moved in opposite directions at the same time. The spores of the middle cell broke their way out first, those of the first and third cells following. For some time after their escape they kept up the jerky movements backwards and forwards, after which they suddenly started off in different directions across the field. The slide was then made into a permanent mount.

Four zoospores each of which had a very delicate wall between it and its neighbors, were observed to escape from a cell.

A large number of megazoospores were measured and the limits of diameter were found to be 6.5 and 7.5 mic.

While the spores were most vigorously active, from 9 o'clock to 12 o'clock A. M., some slides containing them were stained for the purpose of recognizing the cilia. The directions given by Zimmermann (I) for staining the cilia of algae were followed, with the exception that the carbol-fuchsin was allowed to act only three minutes instead of fifteen. Permanent mounts were thus prepared and in this manner the spores corresponding in size to those of the cells just described were seen to have four cilia (Pl. XXXII, fig. 17).

On the tenth day while material in a drop culture was undergoing examination, gonidangia occupying the upper portions of filaments, were seen to contain what appeared to be germinating spores (Pl. XXXII, fig 18). The tubes did not arise from successive spores, but every other one, perhaps, was in this condition. It was noticed that all the germinating filaments from a single branch projected in the same direction and at right angles to the branch. Subsequently it appeared, in a group of sporiferous branches lying together, that all the germinating filaments extended in the same direction. However, exceptions to this rule occur.

The terminal cell of a sporiferous branch often supported a bristle. Pl. XXXII, fig. 24, shows a group of three cells terminated by a short bristle which it is thought may be a detached branch of this kind. On the other hand it may be a very young plate which has itself thrown off a bristle. The hyaline cells have a diameter of 6 mic.

The spores in the lower cells of the reproductive portion seem to germinate first. A detached filament composed of nine cells was noticed in which three of the spores had germinated. These had developed bristles immediately with no intervening cells.

Mention has already been made of certain cells having undergone etiolation. This became quite a common condition among the filaments on pebble "3" to such an extent that it was apparent to the naked eye. By the seventeenth day, certain entire thalli had turned perfectly white. No such occurrence was observable in any of the other material.

Upon the first arrival of the alga it has shown in every case the presence of lime in greater or less quantity. Forming "caps" to the thalli or scattered in microscopic grains through the interior, there is indicated a close relationship between its presence and some physiological function of the plant. From the nature of its structure it appears that its formation takes place after the plant filaments are somewhat matured.

The green thalli contain a relatively small amount of calcareous material while the blue-gray thalli, on the other hand display a large quantity of lime in the form of aggregations or plates of crystals. These plates are in general very irregular in outline. The surfaces are covered with fine ridges arranged horizontally or in concentric lines. Pl. XXXII, fig. 20, shows such a crystal-plate. It is seen to be perforated by round holes in the central portion, while at the ends long tubular openings are present. It is not difficult to see that these tubes follow the general trend of the branches in a free branching filament. The fragment here shown has evidently lain in a position at right angles to the direction of growth of filaments underneath. As a result the tubes or pipes extend in a direct manner through the middle portion, while at the extremities, as would naturally be the condition from the somewhat radial method of branching which occurs in the upper filaments, the pipes run in an oblique direction.

A thin fragment of the lime formation lay in a position to show the perforations in cross section. The apertures

were quite uniform in size, being 5 to 5.5 mic. in diameter. The whole fragment had a diameter of 105 mic. and was about one-half as long. It seemed to be an expansion of a stem coming from the main body of the crystal plate. A similar but smaller fragment is figured (Pl. XXXII, fig. 21.)

The crystal plates as a rule are flat and shelving, the edge on one side being rounded, and on the other somewhat straight. Smaller plates or shelves are thrown out from these as branches.

It may be worth while to note the fact that a large quantity of the material taken from pebble "3" consisted of filaments distorted in a grotesque manner. It was thought to be due to the fact that their growth had taken place *after* the crystal plates were formed, so that a filament pressing with its terminal cell against the resisting surface during a period of rapid elongation, would have been forced back, thus inevitably becoming twisted, bent and misshapen in various ways.

Another condition of quite frequent occurrence is that of an enlargement of the terminal cell or cells of the branches. As shown in Pl. XXXII, fig. 23, these cells are much above normal size. These examples are not of isolated plants. If one filament is observed in this state, its neighbors will quite surely be found in a like condition. No explanation is offered. It may arise from a diseased state of the plant or some outward force may be the cause.

The behavior of the crystals upon being treated with hydrochloric acid shows them to be calcium carbonate. From the time of the removal of the material from the spring, the crystalliferous masses gradually begin to disappear and after a period of three or four weeks no remains of them are to be found.

If one could be in a position to observe personally the conditions existent at the Bellefonte spring and to have ready access to fresh material, it would make a profitable study to find out whether this particular species of Stigeoclonium characteristically encrusts lime when growing in an uncultivated state, or whether it has acquired this capacity only in this particular instance as a result of living in water in which the proportion of calcareous ingredients is such that a deposit would be formed upon any living plant contained in it. It should be noted here, that the other algal plants inhabiting the spring, as far as can be learned, are species of Chara, Oscillatoria and Lyngbya. These are all known to have more or less ability to encrust lime.

It has been impossible to do more with this problem while at such a distance from the spring. It can only be said that the conditions present in the spring seem to meet the needs of the Pilinia stage and that only. When removed from those conditions the plant transforms itself into Stigeoclonium and that in turn changes into the Palmelloid stage.

2. Stigeoclonium Stage: Fifteen days after the Pilinia plant had been under cultivation, a small mass of waving filaments about 3 mm. long was observed on pebble "5." Heretofore, though examined often, nothing but the layer of dull looking plate cells had been observed on this pebble. These filaments were found to proceed from Pilinia plate cells and a thorough investigation of them proved beyond a doubt that the plant was a Stigeoclonium.

A day or two later material taken from pebble "3" showed under the low power, a small spherical Pilinia thallus out of which grew long filaments of the Stigeoclonium type. One of the longest of these, measured 1125 mic. in the portion that projected beyond the general mass. Of this length 625 mic. belonged to the bristle, leaving 500 mic. in the vegetative portion. The upper vegetative cells were 9–10 mic. in diameter, and from $1\frac{1}{2}$ to two times as long. They were entirely filled with protoplasm and chlorophyll. Each contained from two to four pyrenoids and some smaller granules. The filaments with one exception were unbranched. Near the end of this filament a short branch was given off. All the filaments were evidently about to form zoospores.

Subsequently, much of the Pilinia material developed into the Stigeoclonium stage.

The Stigeoclonium thallus showed on an average, a length of 30–35 mm. It is light green in color and so very delicate in appearance, that one finds it difficult to recognize its presence in the water.

A single tuft or mature thallus when examined as a whole (Pl. XXXIII. fig. 1), shows at the base, short Pilinia shoots radiating from the cushion of plate cells. These are relatively few, the majority of them being produced into the long Stigeoclonium threads. These main filaments are simple for some distance from the base and consist of articulations 9–15 mic. in diameter, with a length $1\frac{1}{2}$–8 times as much. At length groups of short, somewhat globose cells begin to alternate with the ordinary long ones, and these are the cells which bear

the branches (Pl. XXXIII. fig. 2). This rule has its exception, sometimes a primary filament may give off several long branches, but no branchlets. When this is the case the branches develop from the upper portion of an ordinary long cell following the example of most species of Stigeoclonium (Plate XXXIII. fig. 1). All the cells of the stem are quite generally constricted at the joints, and considerably or at least slightly swollen at the middle portion. In their contents, the cells resemble very closely those of the Pilinia stage, the amount of chlorophyllous matter in the lower ones being very meagre, while in those of the branchlets it is much more abundant. The chlorophores are generally not so lenticular in form as those of the Pilinia stage. There is seen simply an irregular band of green near the central region of the cell, containing one or in some cases two pyrenoids, and occasionally one or two granules. A division of the pyrenoid into two precedes the formation of a new cell wall at that point. The young growing cells in the upper parts of the branches and those of the branchlets hence contain three or four pyrenoids. When the chlorophores are distinct, they appear as elongated bands, lying parallel to the sides of the filament, or are somewhat disc-like in form, encircling the pyrenoid.

The short cells bearing the branches vary in number from three to seven in a group (Pl. XXXIII, fig. 4). One or all of them may give off branches or branchlets. In general one long branch exactly similar in appearance to the main stem, and several short branchlets occur in a group. The mode of branching is irregular. Occasionally the branches arise in pairs, more generally they are alternate, and sometimes they are given off irregularly from the side of the filament.

The hair-like prolongations which are developed by the Stigeoclonium cells are in all respects similar to those of the Pilinia filaments with the exception that they are somewhat larger and attain a greater length. According to Huber (I) they would be included, together with those of Chaetophora and Draparnaudia, under the term "poil" (hair or bristle). He considers these bristles "to be the result of a reduction of free vegetative branches—the branches which stand upright from the substratum to which the plant is affixed"—and he further observes that this reduction can be limited to the extremities of the branches; or it may extend to the entire branch; or finally it may include the entire number of upright branches, which are then represented by bristles standing up from a creeping

thallus. By including Pilinia as a stage of Stigeoclonium, each of these three types of reduction has its representative as shown by Pl. XXXII, fig. 6, 5, in the case of the first and third examples.

Huber quotes from Berthold (I). "Many species of Stigeoclonium form, in germinating, a creeping "rhizome," more or less branched, upon which develop the upright filaments, which branch in their turn and constitute the point of departure of a series of remarkable reductions". This author further remarks "It is not rare, that in the first stages of development of the *epiphytic* forms of the genus Stigeoclonium, those having the creeping thallus strongly developed, furnish (sometimes side by side with the ordinary raised branches) the upright branches entirely transformed into pluricellular bristles." One infers from this that the phenomenon has not heretofore been observed in species of Stigeoclonium which were *not* epiphytic.

Berthold, as quoted by Huber and Moebius (I), affirms that the cells of the bristle in Stigeoclonium are 10–15 times longer than those of the vegetative tract. The Bellefonte species does not confirm this statement. Some of the filamentary cells are 72 mic. and more in length, while no bristle cell has been observed more than three times this length. It should be noted, however, that the bristles themselves are exceedingly long.

Berthold (*Moebius* I. 84) was also able to develop bristles in great abundance after four weeks' culture in material which at the time of its collection (early in the year) was entirely without them. This corresponds with the behavior of the Bellefonte plant which has been the same in every case.

An increase in the number of pyrenoids in the upper cells of the filaments and branches indicates that the time for the formation of megazoospores is near at hand. A division of the cell contents ensues, so that there now appear rows of cells divided into portions nearly square in outline, densely filled with protoplasm and chlorophyll and containing in general four pyrenoids.

Long filaments composed entirely of zoospore mother-cells are frequently found, either detached or forming continuations of the Pilinia branches. An instance of this was noted in a hanging drop culture. Instead of occupying the terminal region of a Pilinia branch, the reproductive cells extended 200 mic. in length and were limited at each end by ordinary

vegetative cells. In one detached filament, the reproductive portion extended for a distance of 675 mic., then came a few vegetative cells and lastly the bristle. The spores were quite mature, but seemed most so at the middle of the reproductive area, as some here had already escaped from the cells.

One branchlet from a group was prolonged far beyond its fellows and consisted of a row of reproductive cells 125 mic. in length at the end of which were several vegetative cells not yet changed into gonidangia, and the whole terminated by a bristle, 350 mic. in length.

The reproductive cells contain from 1–16 megazoospores each. The spores soon showed a large pyrenoid and a distinct eyespot. In a detached end of a filament consisting of three cells the contents of each cell was divided into two portions which were to become zoospores. The pigment spots of the four spores nearest the end and also the sixth one were situated on the same side (Pl. XXXIII, fig. 5). The fifth pigment spot was on the opposite side. Without exception the large pyrenoids were on the same side of the filament. In another case, two cells of a branch had each two pigment spots facing in the same direction and one cell had two pigment spots facing in opposite directions. Still another branch had cells containing two or four spores each; for the most part the pigment spots alternated.

The megazoospores measure from 5–7.5 mic. in diameter and are from 10–12 mic. in length. In shape they are broadly elliptical or egg-shaped. In general their longest axis lay transverse to the filament. Occasionally they lay with their longest diameter parallel with the filament (Pl. XXXIII, fig. 8).

It is interesting to watch the process of evacuation of the gonidangium. For this purpose a certain cell was kept under observation (Pl. XXXIII, fig. 6). The spores were eight in number and had reached a point where they were distinctly separated from each other and were already evincing a slight activity. This soon gave place to a very energetic movement. Thus each individual spore began a series of almost imperceptible little jerks. These constantly grew stronger until they became to and fro movements in the cell. Finally, all the spores were darting hither and thither in the cell in all directions, around and over each other. Meanwhile the walls of the cell seemed to have become somewhat gelatinized. The force used by the spores in striking against the sides resulted in the walls being stretched out or swollen so that the cell became barrel-shaped in outline.

The cell under observation was 20 mic. long. After an hour of active motion of the spores, its width was 18 mic. At this point the wall at one side gave way. A spore passed out, paused for a second, and darted away. The other seven then followed in quick succession.

A filament was observed while the spores were passing out (Pl. XXXIII. fig 9). From one cell four spores passed out, one after another, through a break in the wall at the upper end of the cell. Then almost immediately eight spores burst through the end of the adjoining cell into the first cell and escaped by the opening made by the former occupants. This indicates that no particular area in the cell wall is thinner or in any way specialised as the spot at which the spores shall break through. Any portion of the end or side wall may serve this purpose. The walls of the second cell were clearly outlined as shown in the drawing. After the spores passed out there seemed to be remaining very delicate membranes which had separated the spores from each other. While the same thing was observed several times, both here and in the Pilinia material, in many instances there was not the least indication of it. All the spores measured 5.5 mic. in diameter and 12 mic. in length. After escaping from the cell and moving about for some time in the water, they sometimes seem to gain in width and lose in length —becoming broadly egg-shaped.

A cell measuring 5 mic. at the end, 15 mic. in the swollen portion, and 22.5 mic. in length contained seven or eight zoospores (Pl. XXXIII, fig. 10). The cell wall seemed to be very elastic, bulging out in different places as the spores changed their position. They were more crowded, and for that reason, probably, did not move so energetically as their neighbors. They did not have the regular and mature form of those in the adjoining cell. In their efforts to escape, the spores used their ciliated end, which seemed to be slightly protruded like a proboscis.

Very often the last one or two spores in a cell do not escape with the rest. This fact does not seem to be due to their cilia being caught, since they move freely about in all parts of the now roomy cell; but it appears that the walls after being burst apart are again crowded together by some movement or contraction of the filament, before all the spores have a chance to escape.

After twelve days' culture indoors, the tanks were placed in the open air, the water being changed morning and evening.

After twenty-four hours, the zoospores were much more numerous and showed a much greater rapidity of motion than heretofore. At 8 o'clock A. M. they were in rapid motion, and remained in that condition for four or five hours. This was in all probability due to their exposure to fresh air and sunshine.

The usual method pursued in staining for the cilia was that of Zimmerman (I) with slight modifications. A mount was obtained in which the moving spores were numerous. After being fixed with the fumes of osmic acid, they were allowed to dry on the slide, and afterwards covered with a drop of aqueous tannin solution which was washed off with water after five minutes. Next the slide was left three minutes (Zimmerman advises fifteen) in a concentrated aqueous solution of carbol-fuchsin. This was again washed off with water and then the slide left to dry. A drop of canada balsam and a coverglass being added, a good permanent mount was obtained.

Another method for showing the cilia distinctly was accidently discovered. In attempting to stain the nucleus in the vegetative cells, Zimmerman's fuchsin-methyl-green method was used. As a nucleav stain it was a failure, in this instance, but the cilia of zoospores contained in the mount were shown very clearly indeed. By this method a spherical zoospore 7.5 mic. in diameter showed four cilia which were 13 mic. in length.

In a cell from an upright filament from pebble "4", a spore was seen 10 mic. in diameter. In the adjoining cell were two ellipsoidal spores 7 mic. in diamter. This is the only instance in which a spore of this size was observed *within* a cell. A number of motile zoospores, however, resembled this one in size, shape and general appearance. They moved slowly. Moreover they possess only one eye-spot as far as observed. By far the greater number of zoospores were 5–7.5 mic. in diameter and egg-shaped. But these larger ones were abundant enough to allow of examination.

By means of the carbol-fuchsin stain many mounts of spores were prepared and studied. In one instance the cilia measured 20 mic. in length.

The glass dish containing the two pebbles upon which the Stigeoclonium megazoospores were being produced so abundantly, occupied a position upon the outer window ledge, so that the light was received from but one direction. On the outer side of the vessel bright green patches lying at the height of the water level were noticed. Upon examination they proved to be masses of young Pilinia plants. The re-

mainder of the inner surface of the vessel was tinged with dull green, which was caused by the presence of the plant in the Palmella stage to be hereafter described.

This behavior of the zoospores suggested a plan for sowing them for the purpose of studying their germination. By the following method an almost pure culture of the Pilinia or Stigeoclonium spores was obtainable:

A small beaker, painted black with the exception of a space about an inch square on one side near the top, was filled with water. In this was suspended a hanging drop cell in such a way that its cover-glass fitted over the unpainted square and presented its under surface to the water. The water covered a portion of the glass. Zoospore-forming material, taken from the pebble at about 10 A. M. when the zoospores were in the most active motion, was placed on the lower ledge of the suspended cell with the expectation that the zoospores in seeking the light would come to rest upon the under side of the cover-glass at the surface of the water. This they invariably did, losing their cilia in a few hours and becoming attached to the glass most satisfactorily. The convenience of this arrangement is apparent. The cell could now be removed from the beaker and placed under the microscope for examination, and returned at pleasure to the beaker or to a moist chamber. If kept in the moist chamber the drop of water may be drawn off and a fresh one added at intervals, without the least danger of displacing or injuring the germinating spores. This cannot be done when the spores have been removed from the sides of the tank and placed in a cell for they will not attach themselves a second time. With the method described, if it were necessary to watch a certain group of spores during a period of several days, a circle was drawn with ink on the top of the cell coverglass within which were the individuals to be studied, and thus they were easily found with the low power of the microscope. Otherwise when the spores are at all numerous in the mount, it is often difficult to find the same ones a second time.

Several hours after the spores had ceased swarming for the day, the hanging cell was removed from the tank and examined. A large number of spores had collected on it at the level of the water. They were quite varied in size and form and each contained an eye-spot near the anterior end and some granules (Pl. XXXIV, fig. 7). The spore is evidently caused to

adhere to the glass when it comes to rest, by means of a gelatinous secretion. It is always seen lying upon its side.

One spore, 7.5 mic. in diameter (Pl. XXXIV, fig. 8), had evidently just come to rest. When it was observed it happened that the water under the cover-glass had evaporated making visible the four very short cilia. A bright pigment spot and a large pyrenoid were present. Other spores whose cilia could not be made out, were elongated slightly, the colorless end becoming somewhat pointed in the process. The pigment spot, which in the moving spore occupied a somewhat anterior position, through this act of elongation had come to lie within the posterior half of the body. The spores which had made the most progress in germinating had fallen off slightly in diameter, but had gained in length, some measuring as much as 15 mic. (Pl. XXXIV, fig. 9).

Twenty-four hours later the spores had, in the case of healthy individuals, developed into two celled plants, each cell with its pyrenoid (Pl. XXXIV, fig 10). Where the division was quite recent, the pyrenoids were discovered situated side by side with the new wall lying between (Pl. XXXIV, fig 10, 11). Fig. 12 affords an example of the division of a pyrenoid into two, preparatory to the formation of a second wall. This filament is beginning to bend, which later is seen to be characteristic. Fig. 13 shows a filament of some length in which the pointed colorless end still remains. In most cases the young filaments at this stage are green throughout.

Notes of the rate of growth were kept for a short time. Taking the average length of spores in a mount, whose length was 12 mic. before germination: at the end of the first day the average length was 20 mic.; at the end of the second day, 33 mic.; at the end of the third day, 60 mic.

On the third day branches began to appear (Pl. XXXIV, fig. 16, 19, 20). When two or more spores lie in contact with, or near to each other, it is not rare for the filaments developed from their germination to become closely entwined and eventually to form portions of the same thallus, (Pl. XXXIV, fig. 21, 25), or a thallus originates from a single spore (Pl. XXXIV, fig. 22, 23). The short primary filament soon produces branches on either side which in their turn also give off branches. A compact plate is the result which maintains a somewhat circular shape (Pl. XXXIV, fig. 24). Sometimes, however, as in figs. 25, 26, the thalli have attained a large size without yet having become compacted together. Sometimes from these large

thalli one or two branches are given off which are so small and thin that one can hardly believe they belong to the same plant.

Five days later thalli of this stage of advancement had developed numerous upright filaments, among them at intervals a group of threads with as great a diameter as those of the ordinary Stigeoclonium filaments. They branched frequently and these branches terminated in a hair.

The greater number of the new plates had not as yet produced these raised branches but were still increasing in size. They showed great regularity in the radial arrangement of their prostrate branches.

A few days later the upright filaments were present in large numbers. The cells near the center of a plate seemed to be first in developing them.

In fig. 27, a group of the creeping branches is seen, which have not yet become crowded together. One branch just in the act of forming upright filaments is shown from side view. Frequently a basal cell is seen to give rise to two branches lying in the same plane. As observed at (a) these may be of different ages.

The basal cells are then capable of developing branches in two planes: *lateral branches*, the cells of which are short and globose or angular, and *upright branches*, with long cylindrical cells. In either case the branches may be dichotomous or monopodial (Pl. XXXIV. fig. 27, a and b.) Therefore in this capacity, the cells of the creeping filaments are exactly homologous to the cells of the upright filaments, since the latter also are able to produce dichotomous branching in the plane of the filament or in a plane at right angles to this (approximately)—the plane of the branching.

Accompanying these upright filaments, there is occasionally to be seen, a long upright bristle (Pl. XXXIV, fig. 27, c).

The filaments of the plate when seen in side view are curved in nearly every instance, making the "bow-shaped row of cells" of which Cienkowski (I) speaks. But he takes the view that the convex side of this bow is directed towards the water, while the concave side is turned to the light and that the branches are turned toward the inside, i. e. that they spring from the concave side. A copy of his drawing of this type of thallus is shown (Pl. XXXIV, fig. 30). The germinating filaments under investigation show an exactly contrary state of things. The branches invariably take their rise from the convex side of the "bow," while the concave side is presented to the surface of the glass (Pl. XXXIV, fig. 29).

Upon another point there is disagreement. In his words: "A plate results in which one can distinguish the branch rows, but in the center are found usually cells united like parenchyma." He illustrates this (*Pl. I, fig. 3.*) Such plates have been seen among the Pilinia material, but not in sufficient numbers to allow of their being designated as a type. In my experience it has been the rule that the cells in the center of the plate (that is, in healthy and rapidly growing young plants) were the first to form branches. Taken as a whole the process of development followed out by the spore in forming the thallus is essentially the same as that described by Cienkowsky.

Fig. 29 shows one plate branch like that in fig. 27, of which the upright filaments have become from 3–4 celled and in one or two cases have branched. Pl. XXXV, fig. 1, represents a prostrate branch showing the characteristic bow shape with its accompanying upright filaments. The cells at the apex appear to be producing branches in both planes, i. e. the prostrate branch is still growing while its cells as soon as formed give off the upright branches. An irregular bit of the thallus is protrayed in fig. 2, with some of the lower cells giving off long bristles, and the upright filaments showing clearly their Stigeoclonium nature. Fig. 3. finally brings to a close the series of forms through which the plant passes from the beginning of germination to the time of fruiting. The figure will be found to closely resemble Pl. XXXI, fig. 1. Thus the final proof of the unity between Pilinia diluta Wood and Stigeoclonium flagelliferum Kg. is produced.

The thalli which were mentioned as growing on the side of the tank toward the light had as their most prominent feature the number and length of the bristles. These rise perpendicularly from the plate, either directly from the basal cells or from upright filaments composed of several cells. Extensive plates are present with no upright filaments but the bristles. Most of the material, however, has upright filaments. In one instance, two bristles are given off by the same basal cell. Some bristles extend horizontally from the plate cells.

The thalli on the sides of one of the tanks were examined from the outside, with a very low power. Their average diameter at that stage was found to be from 50 to 60 mic. The thalli were originally solitary in all cases, as could be seen, and the tendency was to assume a circular shape. When two or more thalli chanced to lie near each other they soon became fused and then an irregular or lobed mass was formed. No filaments

were visible except the long bristles radiating out in every direction. Some of them were 100 mic. or thereabouts in length.

Carefully removing one of the thalli with a scalpel and camel's hair brush, under the same power of the microscope it was found to consist of a plate, the upper surface of which (that is the surface exposed to the water) was convex, while the lower side (that resting on the glass) was concave. From the convex surface the upright filaments stood out in all directions. From many of them very long bristles were produced.

The thalli occurred on all sides of the glass dish, but not at the surface of the water as those in the first tank did. They were scattered on all portions of the vessel walls from the bottom to the surface of the water.

The high power showed the following points: The upright filaments at this stage were in the neighborhood of 37.5–45 mic. in length and 5 mic. in diameter.

The cells were in general 9–12 mic. in length. They were densely filled with protoplasm. were bright, vegetative green in color, and contained a distinct pyrenoid and some granules. The cells appeared to be about to form zoospores. Some were in process of division. The basal cells were 10 mic. in diameter.

A view is given of a section of plate cells in diagram (Pl. XXXV, fig. 7) from the under surface. It shows the position of a single branch (fig. 8) as it lies in the plate.

The sides of the tank containing pebbles "3" and "4" (the material being in the Pilinia stage) were dotted over with small solitary thalli with the same appearance as those which covered pebble "2" which was placed in the herbarium.

Transformation into the Palmella Stage.—The presence of Palmella-like cells has been very noticeable in nearly every mount prepared from the Pennsylvania material. Little notice was taken of them at first, as it was supposed they had nothing to do with the Pilinia. Later, however, cells exactly corresponding to them in size, shape, and general appearance were observed to be connected with the Pilinia plant. The first instance of the kind was seen in a detached branch of Pilinia (Pl. XXXIII, fig. 11). One branchlet, instead of being made up of the ordinary cylindrical cells was composed of ten globular, thick-walled, Palmella-like cells. One was in process of division into halves. The cells appeared to be surrounded by no membrane common to them all, but

there remained in the shape of the branch evidence of the former cylindrical cell the walls of which had apparently gelatinized. The cells were green with chlorophyll, in some portions colorless, and they contained granules of various sizes. They were 10–12.5 mic. in diameter.

A detached cluster of branches was observed for several days in a hanging drop culture. It appeared as if all the cells of a branch were filled with mature spores—all being at the same stage of maturity—and the cell walls in process of gelatinization. These bodies were 12.5 mic. in diameter—in this respect and in their having thick membranes, corresponding to the spores pictured in fig. 11. The spore mother cells were divided into two, and in one case, four portions. They were in the main spherical, but some were angular from being crowded together. They were arranged in an irregular row, or sometimes two rows after the manner of the eggs in Sphaeroplea annulina. An accident happened to the specimen before a drawing could be made.

A third example afforded still more conclusive evidence of the transformation process (Pl. XXXIII, figs. 12, 13.) The cylindrical vegetative cells were observed in the very act of developing into the Palmella cells. All stages are seen on the same branch. The resulting Palmella cells are 12–20 mic. in diameter. The Palmella cells of the plant described by Cienkowski were .012 mm. in diameter. In regard to the transformation process, the behavior of the plant is similar to the one described by Cienkowski.

Material from pebble "4," thirty-five days after being taken from the spring, was seen to be forming in great quantity the Palmella cells from the filamentary cells. Large masses of irregular, or spherical, or elliptical bodies were piled together. They varied from 12–20 mic. in diameter. Many were dividing into two and four portions. They were surrounded by wide gelatinous walls.

Before it was known that the plant was a Stigeoclonium and that this transformation occurred, several references were made in the notes to the effect that a number of times the Palmella cells had been observed lying in a position that would indicate they had been borne on a branch, the walls of which had gelatinized. Also, that they occurred in exceedingly large quantities which could hardly be accounted for in any other way than that they were transformed Stigeoclonium cells.

3. **Palmella Stage.** As has been previously stated, cells of the Palmella type form an ever-present element in the Pilinia material. When the first examination was being made the contents of these cells were noticed to be in process of division and afterwards to pass out as motile spores. No notes nor drawings were taken of this at the time, but before the end of the week, I began keeping notes regarding their behavior as well as that of Pilinia in case they should be found to be a stage of that plant.

Cells of this nature were seen in two conditions: (1) Solitary, either lying entirely alone or in heaps or piles. (2) Connected, either in small groups or in extensive plates.

(1) The isolated cells have the following characteristics: They average from 10–15 mic. in diameter, are in general perfectly spherical in shape, densely filled with chlorophyllous contents containing coarse granules and occasionally others of different sizes. In many cases a portion of the contents is colorless. The enveloping wall is in most cases distinct. When it shows at all, it varies in width from a delicate though firm, smooth membrane to a wide gelatinous band. Near the center of the cell there generally appears a lighter spot.

Some of these cells were frequently seen undergoing divisdivision into 2-4-8 parts. The contents were finally granular. The size of the newly formed bodies varied from 3–7½ mic. (Pl. XXXIV, fig. 3). The pyrenoid lying in the center of the original cell indicates the formation of the first wall by separating into two. These lie opposite each other with the new wall between (Pl. XXXIV, fig. 3a). Another division of each pyrenoid again occurs as four internal spore portions become separated off, and so on until a certain number of spores are formed. A spherical cell 14 mic. in diameter is shown dividing into four portions (Pl. XXXIV, fig. 3b). It occured in a group with others not yet undergoing division and still others already emptied of their contents. With them were seen spores 5 mic. in diameter. A spherical cell 12.5 mic. in diameter contained four spores 5 mic. in diameter, showing eye-spots. Another group was present in which were the large solitary green cells piled loosely together. With them were several colorless cysts of the same size, 13 mic. in diameter. One of these still retained two spores 5 and 7 mic. in diameter.

Plants of this kind taken from pebble "4" were found to be entirely healthy in appearance. The contents were uniformly green in color, coarsely granular, and the outside membrane

was wide and gelatinous. Though piled up together, the cells for the most part were disconnected. Sometimes two or three were connected after the manner of Gongrosira cells (Pl. XXXIV, fig. 2). Some entire heaps had secreted gelatinous walls and already had the appearance of a plate. Thus the first condition merges into the second (2) first by the development of the individual membrane into a mucilaginous substance, second by the coalescence of this substance with that of the neighboring cells, thus forming a continuous layer of gelatine common to the whole group of cells. In this way cells which were lying close together become driven apart a slight distance from each other and have the appearance of being suspended in the gelatine. Their aspect is that of Tetraspora cells except that they are not arranged in twos or fours. In this stage of the process they are more nearly spherical in form and are fresher looking than at a later period. In general nearly one-half of each cell is almost colorless.

Later these cells lose their fresh color and become dull and dead looking. The gelatinous layer between them becomes contracted into thin leathery division walls, common to the cells on either side. It is believed that this condition of things precedes the development of microzoospores. At any rate, at the end of three weeks the sides of the glass tank containing pebbles "6" and "7" had acquired a dull green color which was proved to be caused by the presence of these plates with the appearance just explained. They were dividing into microzoospores, to the number of 4–8 in a cell (Pl. XXXIV, fig. 4). This was the first instance of cells *in plates* developing zoospores, though a most exhaustive search had been made for the purpose of finding this condition. The mother-cells in the figure given, were 12-15 mic. in diameter in the main; some were very much smaller—4–mic. in diameter. Those from which the zoospores had not yet escaped were generally spherical and swollen. The empty ones were more angular and collapsed. Around the edges of the large plates and also from cells in the interior, there grew out branches of the Pilinia type the cells of which varied from 4–10 mic. in diameter. These filaments did not stand upright, as is usual, but occupied the same plane as the plate. A portion of a plate is shown (Pl. XXXIV, fig. 4) in which appear a vegetative peripheral plate cell with its large central pyrenoid, embedded in the chlorophyll and granule-bearing protoplasm. From its outer side extends a filament in all respects like an ordinary Pilinia

filament, except that it does not stand upright, with cells in healthy growing condition. On the interior its neighbor consists of a similar cell through more mature which through the swelling of its contents has attained a globose form. The process of division is far enough along to allow four portions to be clearly discerned and four eyespots are perfectly apparent. They are seen to lie as far from the center as possible. On one side lies a very angular cell, nearly twice as long as wide, containing six zoospores. They are 3.5–4 mic. in diameter; their eyespots are distinct. A faint though quite distinct movement of the zoospores within the cell was perceptible, but though this and other material was watched during the remainder of the afternoon, no spores were seen to escape from a cell. This probably was due to two reasons: first the afternoon is not the natural time for the escape of motile spores, the best time for observing them being from 8–12, A. M.; second, the material had lain already for some time under the coverglass, so that the poor supply of air and lack of fresh water very likely weakened the natural liveliness of the spores On the opposite side from this was an empty cell from which the spores had escaped probably during the morning hours. These empty cells were very abundant throughout all the plates examined. In the same drawing can be seen such a cell occurring as the basal cell of a filament proving that a basal cell may also be a reproductive cell. However this may be, the combination of, or the relation between, basal cell and filament, in this case is not the same as in the Pilinia basal cell and filament. For this filament is either a Pilinia filament not yet transformed into Palmella cells, or it is the product of a Palmella cell, while the basal cell is certainly a Palmella cell. On the other hand a Pilinia filament as well as the Pilinia basal cell may be the product of germination of a spore.

It was expected on the following morning to make a more thorough study of the spores and secure other drawings. But when this examination was made the material seemed to be disorganised in great part, though the conditions to all appearance remained unchanged.

Although for the reason stated above, the subsequent behavior of the microzoospores has not been so closely studied as that of the megazoospores, yet by means of staining, the fact has been clearly brought out that a number of small spores closely resembling those in the plate and solitary cells, are present in nearly every mount of the material containing these

cells. The spores agree in size. They are possessed of only two cilia (Pl. XXXIV, fig. 5). In several mounts a zygote was seen. The first one noticed contained two distinct pigment spots and was bilobed at the lower end, showing conclusively that it was a case of fusion (Pl. XXXIV, fig. 6 a). The number of cilia could not be determined but was supposed to be four. In another mount in which many of the plate cells were empty, a spore with two eyespots was seen (fig. 6 b). Near by was an elongated body, its shape giving it the appearance of being made up of two spores placed end to end. In each end there appeared an eyespot, (fig. 6 c).

One permanent slide shows a microzoospore 4.2 mic. in width, 5 mic. in length, with two cilia. Another spore is 2.5 in width, 6.25 mic. in length and with two cilia. Another is 4.5 mic. in diameter and has two cilia. Still another, 4 mic. in diameter, 7.5 mic. in length, is biciliated.

Since the material is remarkably pure, containing as far as seen, only the Stigeoclonium, Pilinia and Palmella stages of the main plant, together with a few Pediastrums and Diatoms during the last of the period of cultivation, it seems proper to connect these biciliated spores with the microzoospores developed in the plate cells.

In addition to this there is a further demonstration of this supposition. Pebbles "6" and "7" were kept in a tank by them selves during the entire time. They were at first discovered to be coated with very extensive layers of the plate cells which looked very much like Coleochaete plates. Several times thereafter a microscopic examination was made, but nothing new was noted. On the morning of April 27th, while changing the water in the tank, an elongated streak of bright green color was noticed on the side of the dish facing the light which followed the surface of the water. It was caused by the presence of young Pilinia thalli. No material in the Pilinia or Stigeoclonium stage could be found in the tank. This seemed to prove that the young Pilinia thalli resulted from the germination of the microzoospores developed in the palmelloid cells. Cienkowsky's observations brought him to the conclusion that the microgonidia of the Palmella cells developed into the original filamentous alga, but he was unable to determine whether the germination always followed the same course. Compare also in this point Reinhart (I).

Stigeoclonium flagelliferum KG.—*Pilinia diluta* WOOD Cont. F. W. Alg. N. A. 211, 1872.—Floccose caespitose, pale yellowish green, 5–30 mm. in length; filaments somewhat fasciculately branched, rarely almost naked, 9–15 mic. in diameter, with articulations more or less swollen, 1½–8 times longer than the diameter; chlorophores narrow, light green; branches in lower portions in groups of 2–5 on special short cells, rarely opposite, flagelliform, somewhat erect, with very long bristles, in upper portions generally solitary, short, with terminal cells either subulate or piliferous. During Pilinia stage, encrusted with calcium carbonate.

In quiet spring water, Bellefonte, Pennsylvania.

Coll. Miss Ella Levy. 21 Jan., 3 April. 1896.

REMARKS: To avoid adding to the confusion already existing in the genus Stigeoclonium, it is thought best to place the plant which has been undergoing investigation in the above species, although it is not entirely in agreement with it. It does agree in one of the main points, that of forming groups of short, branch-bearing cells. This is, as I understand it, the meaning of the phrases: "ramis inferioribus 2-5 approximatis" of De-Toni (iii,200) and Rabenhorst (ii,379) and "branches flagelliform, opposite, on distinct cells, shorter and more oval than the others of the filaments" of Wolle (ii, 113). As this is a characteristic of no other species, to my knowledge, it seems necessary to connect it with that name.

General Considerations:—It must be explained that the term "Pilinia stage" has been used merely as a matter of convenience. The first stage may be understood to be simply a modification of the second. The development of the individual into the one or the other form depends, it would seem, merely upon surrounding conditions. When living in the waters of the spring, a low Chaetophora-like habit is retained which with the accompanying secretion of carbonate of lime results in the formation of a crust. A removal from this water causes the plant to assume the ordinary Stigeoclonium appearance. There is no regularly recurrent spontaneous change from one into the other.

That the life-history of Stigeoclonium includes a true Stigeoclonium stage and Palmelloid stage is a fact that has been known since the time of Cienkowsky's investigations. The observations recorded in the present paper show the Stigeoclonium stage in itself to be in a marked degree subject to variation.

With this fact in view it is not difficult to account for some of the "new species" among the genera related to Stigeoclonium. In particular it is believed that Pilinia diluta Wood, Chaetophora pellicula Kjellman, and perhaps some of the species of Endoclonium are forms of Stigeoclonium. Stigeoclonium pygmaeum of Hansgirg (I) approaches the Bellefonte plant more nearly than any other species in that it is coated with lime, its branches sometimes 2–3 approximate and its trichomes altogether similar in character. But this is an epiphyte or endophyte living on Ranunculus, Lemna, and other aquatic plants.

This belief is strengthened by various observations found in descriptions of this genus. Dr. Wood (ii. 206. Pl. 19, fig. I.) himself states that a Stigeoclonium, which he watched for several seasons, in its earlier state "appears at times to possess the characters of a young Chaetophora, forming a small gelatinous base out of which the threads soon escape as they lengthen." His figure might well be taken as a representation of a Pilinia developing Stigeoclonium filaments.

A paragraph from Wolle's (I) notes upon S. fastigiatum Kg. is as follows: "Some of the species of Stigeoclonium are very closely related to species of Chaetophora, as is evident from personal observation. Referring to Plate CIII, figs. 1, 2, two thalli of Chaetophora pisiformis magnified about 250 diameters. These show a few of the radial filaments, normally imbedded in a firm gelatinous mucus, extending beyond the mucous tegument; this figure, (1, 2,) is such a filament more fully developed, drawn with all of its branches; it is one of many which occurred in the same pool; Chaetophora also was prevalent in quantity. This observation may open the inquiry, 'is this a normal process of development? Is the plant a Stigeoclonium or a Chaetophora? Or is the latter a mere condition of development of the former?'

"Plate CII, figs. 1–3 and 5–8. Other forms developing from Chaetophora, comp. Stigeo. longipilus, and Stigeo. radians."

In the following description, that of S. longipilus Kg., he again touches upon this point. "There are two distinct forms of this species, the one 8–10 mm. long, represented plate CII, figs. 1, 2, 3, with long bare stems and bushy tops. Kirchner remarks that the species may represent a transition state, going over to Chaetophora. Personal observations prove the reverse, Chaetophora developing Stigeoclonium." * * * "Plate CII, figs. 5-9, are very much elongated filaments of

Chaetophora, evidently going over to or developing Stigeoclonium."

Wolle also suggests that his specimen of S. radians Kg. is "evidently related to Chaetophora." Many of his illustrations show interesting resemblances to the Pilinia growth. See his *Pl. 100, fig. 1. Pl. 102, figs. 5–8. Pl. 103, figs. 4, 5, 8, 9, 10.*

In describing the species S. tenue, Cook (1) quotes from Harvey, " At first the filaments are enclosed, in the manner of a Chaetophora, in a common, somewhat definite gelatine; afterwards, on its bursting, they issue from it like a Conferva, but are at all times very gelatinous."

It is certain that a study of Stigeoclonium and Chaetophora plants during the entire time of their vegetative and dormant periods would be productive of facts which it is necessary to know before the determination of the species can be put upon a firm basis.

I wish to express my gratitude to Professor Conway MacMillan, Mr. David F. Fortney, and, in particular, to Miss Ella Levy, who by her quick insight and untiring efforts to attain satisfactory results, has enabled me to make a study of this plant.

SUMMARY.

1. *Pilinia* is a form genus but its connection with the Phyeochromaceae is not apparent.

2. *Pilinia diluta* Wood is a stage of *Stigeoclonium flagelliferum* Kg. Its development is due to local conditions.

3. Calcareous secretions are peculiar to the Pilinia stage of this species and perforated crystals together with amorphous particles of $Ca\,CO_3$ are distinctive.

4. The formation of bristles seems to be uncharacteristic of the normal Pilinia but arises under culture.

5. Zoospores of two sorts are present in the life history, megazoospores common to the Pilinia and Stigeoclonium stages and microzoospores developed by the Palmella stage.

6. Upright filaments grow from the convex rather than from the concave side of the germinal plate.

7. Conjugation between microzoogametes results in the production of a planozygote.

8. In the Pilinia stage the number of megazoospores does not exceed four in a gonidangium, while in Stigeoclonium the number goes as high as sixteen.

9. The Palmella stage may be developed either from basal or erect Pilinia filaments or from Stigeoclonium filaments.

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EXPLANATION OF PLATES.

Plate XXXI.

Fig. 1. Pebble "1" from Bellefonte spring, two-thirds natural size. Thalli forming an almost continuous stratum.

Fig. 2. Pebble "2". Thalli forming isolated discs.

Plate XXXII.

Fig. 1. Portion of mature thallus in Pilinia stage. Row of plate cells bearing upright filaments the terminal cells of which are developing gonidangia. (X 300).

Fig. 2. End of branch showing dichotomous branching like that of a Chaetophora. (X 300).

Fig. 3. Another example of dichotomous branching. (X 300).

Fig. 4. Bristle terminating upright filament. (X 300).

Fig. 5. Bristle developed directly from basal cell. (X 300).

Fig. 6. Branch showing how vegetative cells taper down to width of bristle. (X 300).

Fig. 7. Branch showing cells with contents dividing up into megazoospores. (X 300).

Fig. 8. Reproductive cell given off from upper portion of filamentary cell at right angles to filament. (X 300).

Fig. 9. Similar cell given off from lower portion of filamentary cell. (X 300).

Fig. 10. Cell containing but one megazoospore. (X 300).

Fig. 11. Cell containing two megazoospores. (X 300).

Fig. 12. Cells showing spores crowded together. (X 300).

Fig. 13. Cell containing four megazoospores. (X 300).

Fig. 14 and 15. Gonidangia appearing large and roomy. (X 300).

Fig. 16. Gonidangium appearing crowded. (X 300).

Fig. 17. Megazoospores. (X 300).

Fig. 18 and 19. Sporiferous branches. (X 300).

Fig. 20. A crystal plate of calcium carbonate showing apertures made by Pilinia filaments around which the lime is secreted. (X 300).

Fig. 21. A transverse section of crystal plate. (X 300).

Fig. 22. Branch with crystal fragment in natural position. (X 300).

Fig. 23. Branch showing enlarged terminal cells. (X 300).

Fig. 24. A group of cells, terminated by a bristle, which may be a sporiferous branch. (X 300).

Plate XXXIII.

Fig. 1. Portion of mature thallus in Stigeoclonium stage. (X 287).

Fig. 2. Upper portion of primary filament showing ordinary elongated cylindrical cells alternating with groups of branch-bearing short cells. (X 160).

Fig. 3. Filament showing general aspect of plant with characteristic mode of branching. (X 29).
Fig. 4. Group of short, branch-bearing cells in detail. (X 300).
Fig. 5. Cells with five spores having pigment spots facing in same direction. (X 300).
Fig. 6. Megazoospores moving actively in the cells thereby causing the walls to become distended. (X 300).
Fig. 7. Showing spores in early stages of development. (X 300).
Fig. 8. Spores lying with their longest diameter crosswise of the filament. (X 300).
Fig. 9. A cell through the end wall of which the spores escaped passing out through a second cell. (X 300).
Fig. 10. Cell containing zoospores in motion the wall irregularly distended according as the spores changed their position. (X 300).
Fig. 11. Detached branch of Pilinia thallus, showing one branchlet undergoing transformation into Palmella state. (X 300).
Fig. 12, 13. Vegetative cells in the act of developing into Palmella cells. (X 300).

Plate XXXIV.

Fig. 1. Further transformation of cells shown in Plate III, fig. 13. (X 300).
Fig. 2. Isolated cells becoming connected by means of the thick gelatinous coatings. (X 300).
Fig. 3. Isolated cells dividing into two and four parts. a. Division of contents into two portions accompanied by the separation of the pyrenoid. b. Division into four portions of contents and pyrenoids. (X 300).
Fig. 4. Plate cell developing zoospores. (X 300).
Fig. 5. Microzoospores. (X 300).
Fig. 6. Zygotes. (X 300).
Fig. 7. Megazoospores of Stigeoclonium.
The following are all developmental stages of megazoospores forming thalli:
Fig. 8. Spore in the act of withdrawing cilia.
Fig. 9. Spores showing pigment spot in posterior portion due to the elongation of hyaline end.
Fig. 10. Further growth accompanied by division into two cells.
Fig. 11. Showing recent division with pyrenoids lying close together on opposite sides of the new wall.
Fig. 12. Division of pyrenoid into two portions preparatory to formation of wall.
Fig. 13. Filament with hyaline end of spore still visible.
Fig. 14. Filament of three cells showing the tendency to curve.
Fig. 15 and 16, 17 and 18, 19 and 20. First appearance of branching.
Fig. 21. Three unbranched filaments becoming connected into one thallus
Fig. 22 and 23. Showing thallus developed from a single spore.
Fig. 24. Thallus building up a somewhat circular plate.
Fig. 25. Two filaments combined into one thallus. Cells very large and cylindrical for the most part, instead of globose.
Fig. 26. Filament with numerous branches.
Fig. 27 and 28. Prostrate branches forming upright filaments.

Fig. 29. Side view of prostrate filament showing upright branches borne on convex side.

Fig. 30. Copy of Cienkowski's figure 19, pl. 1, Bot. Ztg. 34, 1876. Side view of prostrate filament showing upright branches borne on concave side.

PLATE XXXV.

Fig. 1. Creeping filament showing characteristic "bow-shape."

Fig. 2 and 3. Pilinia plants, the latter having arrived at the fruiting stage.

Fig. 4, 5 and 6. Showing an example of different growth in young thalli.

Fig. 7. Under surface view of a plate (in diagram). Showing position of a single branch.

Fig. 8. Same branch from nature.

XXXVIII. POLLINATION AND REPRODUCTION OF LYCOPERSICUM ESCULENTUM.

Bruce Fink.

The experiments presented in this paper were nearly all performed three years ago, and it was then the purpose of the writer to carry on the work through several years so as to include experiments on reciprocal crossing, close-pollination, atavism and the prepotency of foreign pollen. It has not been possible for me to carry on such experiments during the intervening years because not permanently located during the season where such work must be done. Hence, since there is much of interest in the single year's work, it is thought best to publish it, hoping that the experiments which could not be completed in a single year may be brought to a conclusion at some future time.

I shall not attempt to enumerate the various papers consulted in this work. Though a few of the experiments described below have been tried before with tomatoes and some of the remaining ones with other plants, I need not give references to the published accounts, which are well known to botanists generally. So far as I can ascertain, others of the experiments have never been performed before. Of those that have been tried, the results here recorded are not all in accord with those published previously.

During experiments in pollination, the plant operated on must be covered while being used, and it is an advantage to know just how long the plant must be under the screen, in order to be certain that it is neither exposed to wind and insects too soon nor kept covered longer than is necessary to The experiment to ascertain the time necessary was conducted as follows. Nine tomato flowers were castrated by removing the stamens and marked (1), after twenty-four hours another nine were castrated and marked (2), and after another twenty-four hours a third nine were treated in the same way and marked (3). The twenty-seven were pollinated at once so that one third were pollinated forty-eight hours, another third

twenty-four hours and the last third immediately after castration. At the end of twelve hours the styles were removed from one third of each lot; at the end of eighteen hours the second third were treated in the same way; and at the end of twenty-four hours the remaining third. The number of hours intervening between pollination and removing the style was marked on each card. The markings on the cards were 1-12, 1-18, 1-24, 2-12, 2-18, 2-24, and 3-12, 3-18, 3-24, and there were of course three cards for each marking. The tomatoes which matured bore the following cards; 1-12, 1-12, 1-18, 1-18, 1-24, 1-24 1-24, 2-24, 2-24, 3-24. Thus twelve hours was found to be long enough for the pollen-tube to pass through the style in most cases when the stigma was mature when pollinated. Later, I tried six and nine hours, allowing forty-eight hours to intervene between castration and pollination. No fruit developed in the last two experiments.

Some very interesting experiments were tried to ascertain how much care must be used in order to get the pollen on the stigma at the proper time. Two questions of interest arise. One is the length of time that the stigma is in such condition that pollen placed on it will be effective. I found the time to be longer in large flowers than in smaller ones and longer in monstrous flowers than in normal ones. I suppose this is because it takes the large pistils longer to reach maturity and begin to wither. The time must be counted from the moment the bud opens enough to expose the pistil, which is usually protruded somewhat beyond the stigma. The stigma is not in the best condition for holding the pollen at this time, but a sufficient amount adheres, is more effective and passes through the style sooner than when placed on the stigma later. This was very evident in a case in which the stigmas were pollinated as soon as the flowers had been castrated and before the anther-cells had opened. The number of tomatoes produced was larger than from flowers pollinated when the stigma was more mature, and the ovaries began to enlarge sooner than in cases in which flowers of the same age were allowed to stand longer for the stigmas to get in better condition for pollination. Pollen placed on the stigma past prime makes very slow work if effective at all. Counting in the way indicated above, the time is from four to eight days, and during the first day or two the flowers cannot be close-pollinated as the pollen-sacs are not yet open—an arrangement favoring cross-pollination.

The other part of this experiment is to find about the same facts for the pollen. I found beyond doubt that it is not effective so soon as the stigma of the flower will hold the pollen-grains. To ascertain this, I castrated several flowers just opening and used their pollen to pollinate other castrated flowers. I also pollinated the former castrated flowers with mature pollen. At this stage the pollen-grains were not effective in a single instance. But the stigmas were acted on by the mature pollen, producing fruit. To ascertain how long the pollen retains its vitality, I placed some in a box and pollinated castrated flowers with it for seven days in succession. It had lost none of its potency on the seventh day. Seven days is surely long enough to give every chance for cross-pollination by the pollen carried by the bees, and also the pollen may remain on the stigma seven days while the latter is developing if necessary. After the seventh day the pollen begins to lose its vitality and after the fourteenth will not germinate.

Another experiment was the study of the anthers to ascertain when and how the pollen-sacs shed the pollen. When the corolla begins to open the stamens are of a greenish-yellow color, and the sacs are completely closed. In about two days the stamens have assumed a bright yellow color, and the sacs are beginning to open. The best time to get pollen for artifical pollination is soon after or just before the sacs begin to open, when it is easily scraped out on a knife-blade and transferred to the stigma of another flower. The average time required for sacs to begin to open after the corolla has started to expand is two days, but there is a considerable amount of variation in the time due to the size of the flower and to the hygrometric state of the atmosphere. The pollen-sacs open sooner in small than in large flowers, and sooner in dry than in wet weather. In very dry weather while castrating small flowers as those of the Red Cherry tomato, or the Yellow Plum tomato, as soon as the corolla has begun to open, the anthers occasionally snapped open, and the pollen could be seen flying about like dust. It will be seen that the safest time to castrate is on a rainy day or while the dew is on, and that the best time to pollinate artificially is in the dryest part of the day.

Seventy-five flowers were castrated and left to the influence of wind and insects. Some were castrated just as the calyx was beginning to open, others as soon as the corolla had begun to open, and the rest after the latter had fully expanded. All

the stigmas came to best condition for pollination; but of the seventy-five flowers only one produced fruit, and this was a flower of the Yellow Plum tomato that had been castrated just after the corolla had expanded. I cannot be certain that this small flower was not accidently pollinated in castrating. Besides the one matured fruit three ovaries started to grow and aborted at about one-fourth the size of a pea. The failure to get better results from castrated flowers, taken with the fact that flowers confined alone under a screen are as uniformly pollinated as those not confined, seemed to indicate that tomatoes are usually close-pollinated; but later results tend to prove that they are not in so many instances as was supposed at first.

It was thought that the flowers might have been considerably injured in castration and that the exposed pistil might have suffered from the heat of the sun. To ascertain the facts as nearly as possible all but one stamen were removed from about fifty flowers. They were nearly as uniformly pollinated as those not treated. This experiment, as well as the fact brought out later that castrated flowers, when pollinated by hand, produce fruit as uniformly as those left to nature, proves that the injury is not considerable.

The study of the relation of insects to cross-pollination of tomatoes was a very interesting one. Various kinds of Coleoptera, Diptera and Hymenoptera were observed, but none visited the flowers more than other parts of the plants. I watched for Lepidoptera at various portions of the day, but did not find a single species at work on the tomatoes. I watched the humble-bees repeatedly at work. One or more were in the patch at almost any moment of the day, and sometimes as many as a dozen were working at once. They go from flower to flower, visiting about six in a minute. This slowness as well as the rapid movements of their maxillae and limbs, show that they are gathering pollen. In the work they stand over the top of the stigma, turning themselves about upon it. As the stigma usually extends beyond the stamens it is the more probable that the bees must pollinate some of the flowers. To make sure that they get the pollen I examined different portions of the body under the microscope and found the pollen-grains on every part examined, so that any part of the body coming in contact with the stigma might effect a cross. Besides the pollen scattered over the body large masses were found on the posterior tarsi and tibiæ. To make certain that this pollen was not injured by the bees I gathered the pollen from the posterior

limbs of one and placed it on castrated flowers, which produced fruit.

Cucumbers were growing beside the tomatoes, and the humble bees preferred the flowers of the latter though occasionally seen in the cucumber patch. In no instance did I see a bee pass from one kind of plant to the other. A bee working on tomato flowers when disturbed went to another tomato flower, and if driven from the patch, did not stop for other kinds of flowers growing in the vicinity. Red clover was growing along one side of the patch and even this did not tempt a bee that had been working on the tomatoes. Of course the fact that the bees do not pass from one kind of flowers to another helps cross-pollination very materially.

My seventy-five castrated flowers left exposed were not pollinated by bees for the reason that they do not visit castrated flowers. I purposely castrated part of the flowers of a vine by removing both stamens and corolla, another part by removing the stamens only and left the remaining flowers uncastrated. I found that the bees pay no attention to flowers castrated in the first way, approach those castrated in the second way, but seldom so much as touch them before they find the stamens gone and pass on.

Tomatoes are seldom, if ever, crossed by the wind. If they were, I should certainly have gotten more tomatoes from castrated flowers. Mr. C. J. Pennock writes of shaking the pollen off, into a wooden vessel of his own make, to use for pollinating flowers grown in doors in winter. In flowers grown out of doors, the pollen escapes from the pollen-sacs as fast as they open; and large amounts of it must blow about as pollen cannot be gathered from garden-grown plants in the way described above in any considerable quantity. Some of this pollen in the atmosphere must fall on the stigmas, and I can only account for the fact that fertilization is not effected in this way by supposing that more pollen is required to produce fruit than finds its way to the stigma by being blown about in the air.

Experiments were carried on to find the causes of one sided fruit. Tomatoes with this defect noticeable are not common on garden-grown vines except in those which develop from monstrous flowers, though Prof. L. H. Bailey finds it quite common in winter-grown fruit. Suspecting the cause to be that the pollen is not deposited on all parts of the stigma, I tried cutting off one side. The result is usually a one-sided tomato, but not always. Later I got fruit in about one case in ten where I had

cut off the stigma entirely just as the bud was opening. It appears from this that the pollen will occasionally germinate on the cut end of the style after the stigmatic surface is removed, hence my failure to get one-sided fruit in some instances when one side of the stigma had been removed. I also tried pollinating on one side only and got one-sided fruit as a result.

The Handsomest and Best tomato was experimented with as follows: Twenty-five flowers were castrated as fast as they began to open and were pollinated with pollen from as many different varieties of tomatoes. Fifteen mature tomatoes resulted and four more aborted after beginning to grow, probably from insufficient pollination. The other six severed their connection with the vine at the joint of the pedicel. The number of failures was no greater than in flower clusters that were marked and left to natural processes of pollination. In the experiments each stigma was pollinated only once. Later I tried crossing the Tree tomato, pollinating each castrated flower three days in succession. The result was fifteen tomatoes from sixteen castrations.

For the purpose of studying the offspring of a cross the Tree tomato was crossed with the Plum-shaped Yellow, the Pear-shaped, the Red Cherry and Yellow Cherry varieties, as these represent the principal differences between the Tree tomato and other varieties as to shape and size of vine, fruit and leaves. The seeds were planted the next year, and I could not see that the vines, leaves or fruit showed a tendency to imitate the plants bearing them more than that from which the pollen was taken for pollination. The fruit was about intermediate between the two plants crossed. However, more observation than I was able to make is necessary to settle this point.

It has been supposed that crossing produces a difference in the size, shape and color of the tomato resulting from the cross. The largest tomato produced by crossing the Handsomest and Best was from a cross with the yellow Cherry tomato, which was my smallest variety. The crosses with the Large Yellow, Yellow Cherry and Yellow Plum-shaped varieties produced fruit as deep red as those not crossed. A cross with the Yellow Plum-shaped tomato produced a tomato which happened to be more flattened than the Handsomest and Best tomatoes usually are instead of a longer one. Close observation of a large number of tomatoes from crosses seems to show that the size of the fruit is slightly increased and that the crossed

fruits have a greater tendency to be irregular than those not crossed.

It has already been stated that flowers confined under a screen pollinate themselves. In these experiments only one bud was allowed to open under the screen during the time of the experiment, and the cover was left over the plant a week because the flowers were not castrated and were therefore more likely to be crossed. The first tomato produced in this way was one-half the usual size of the variety and contained forty-eight seeds, the average number of seeds for the variety being more than two hundred. The results were not always so marked, but on the whole, the fruits produced in this way are below the average size and usually contain fewer than the average number of seeds. The results as to the vines and fruits from such seeds could not be obtained the first year.

I tried the effects of using large and small amounts of pollen with the following results. My tomatoes produced from large amounts were large and regular, produced a large number of seeds and did not fail to come to maturity in a single instance; while those from small amounts were smaller in size, had fewer seeds, were not so regular in shape and several stopped growing at about the size of a pea.

I tried pollinating the castrated flowers of the Red Cherry tomato with the pollen of Physalis pubescens, Datura stramonium and Solanum nigrum, making about fifty pollinations for each. With the last two, the ovary started to grow in two or three flowers, but they invariably aborted. With the first, I thought I was getting a fruit to develop fully. I got a fruit about two-thirds the usual size of the Red Cherry tomato, which contained only six seeds. I planted two of the seeds the next year and got the Red Cherry tomato, so this must have been an instance of accidental and insufficient pollination in castration. It is very probable that the instances in which the varieties started to grow were also cases of insufficient pollination by accident and that the pollen of the other species mentioned above had no effect whatever.

Of two flowers pollinated at about the same time, one is some times half grown before the other makes more than enough growth to make certain the fact that fertilization has taken place. The one that makes this rapid growth from the start ripens nearly as much in advance and is larger than the one that stops growing for a time. Other ovaries become aborted at about one-fourth the size of a pea, but hang on the vines for

a month or two. It is certain that these have been pollinated because flowers castrated and not pollinated always drop off in a week or ten days from the time of castration. I think there are two causes for this difference in development, i.e. insufficient pollination and lack of sufficient nourishment. The first, I think, is proven by the fact that in trying the effect of different amounts of pollen it was those flowers which received small amounts that aborted. As to the second, it is usually the flowers farthest from the base of the cluster that stop growing for a time or abort. The fruits nearer the base begin to grow first and take most of the nourishment till fully grown.

The process of castration was used so frequently in the experiments that a description of it will be in order. The best time to castrate is just when the flowers are beginning to expand. When the flower is fully expanded there is danger of accidental pollination in castration, or that it has been already pollinated. Also the tissues are much softer just as the corolla begins to expand so that the stamens are easier to remove at this time. One way to castrate is to pull off the corolla as the stamens come with it. Another is to pull off the stamens one at a time with small forceps. By the first method the stamens are pulled past the stigma, and in some small tomato flowers there may be remote possibility of accidental pollination even at this time. By the second method the stamens are pulled directly away from the stigma, and the danger of accidental pollination is thus largely avoided.

The frames on which the screens were spread in these experiments were three and one-half feet square on the ground, and four feet high. This was large enough so that the vines did not touch them during the early part of the season when the experiments were performed. I made my first screen of mosquito bar, but threw it aside for others made of cheesecloth, on account of the smaller meshes. I do not know that the change was necessary, and could not see that the plants were influenced in the least even by the latter kind of screen.

XXXIX. A RE-ARRANGEMENT OF THE NORTH AMERICAN HYPHOMYCETES.

ROSCOE POUND and FREDERIC E. CLEMENTS.

In working over the *Hyphomycetes* of Nebraska for the forthcoming part 8 of the Flora of Nebraska, we were at once confronted with the question how to arrange the group. In dealing with the species reported from Nebraska we have been compelled to go over all the genera and a large number of the species reported from North America, and in so doing have become aware of many grounds for dissatisfaction with the prevailing arrangement.

We might indeed have been content to follow the arrangement of the Sylloge Fungorum, which has come into general use. This system is admirably adapted to finding forms and locating them in their proper place in the system. As a practical key, its utility is not to be questioned. But such an arrangement does not commend itself, even in a group like the *Hyphomycetes*. Moreover, in practice, the Saccardian system is often somewhat unsatisfactory, so that it seemed to us at least worth the while to make a further attempt to bring order from the chaos prevailing in the group. When species have to be "sought patiently under many genera,"* it would seem that further labors to define the genera are not misspent. In no group, indeed, are the genera more in need of thorough revision. Being composed solely of form-genera — conidial and chlamydosporous forms of *Ascomycetes*, with a few stray members of autonomous groups such as *Gymnoascaceae*, *Exobasidiaceae*, etc.,—the *Hyphomycetes* are properly enough left to drift for themselves, and receive attention chiefly from collectors. The diverse forms which the same fungus often assumes either successively or at the same time, add greatly to the difficulty of defining genera or even species. Fungi closely related in their mature fructification differ widely in their conidial

*Syl. Fung. 4:1.

forms, and even the conidial forms of the same genus differ so greatly as to be placed in the most diverse groups when found only by themselves. It is practically impossible to arrange the form-genera of the *Hyphomycetes* according to the mature forms. A considerable number are now known in all stages. For many species the perfect forms may be guessed at with more or less certainty. For more, they cannot be stated at all. In the case of a large part of the reported species the perfect forms are wholly unknown, if there are any. Such an arrangement being out of the question, the only plan would seem to be to arrange the forms according to their apparent structural relationship, as we would do in an autonomous group. This we have attempted to do. When we speak of relationship we must be understood as referring solely to structural similarity. In the case of autonomous forms this would be taken as an index to genetic relationship. In such a group as the *Hyphomycetes* it can only be used as a basis of arrangement in dealing with forms with which collectors must constantly have to do.

It may be asked whether in such a group as the Imperfect Fungi, an artificial arrangement after the manner of a key, such as that adopted by Saccardo, is not the best. In a certain sense there can be no natural arrangement of such a group. But on the other hand a large portion of the *Hyphomycetes* have a certain autonomy. They are constant, and they develop and reproduce themselves indefinitely without attaining any different form. Besides, the Saccardian arrangement is by no means as easy of application as it may appear. Phragmosporous genera with species having continuous conidia are not uncommon, the line between *Didymosporeae* and *Phragmosporeae* is always shadowy, and *Dictyosporeae* are very apt not to have uniformly muriform spores. Experience with this arrangement soon convinces one that unless he knows a genus, the neatly planned system will often do little towards enabling him to identify it.

For such reasons we have determined to attempt a re-arrangement of the genera based on structural similarity and relationship, endeavoring to treat the form-genera in the same manner in which one would deal with autonomous groups.

In the Saccardian arrangement the *Hyphomycetes* are divided into four families, the *Mucedineae* in which the sporophores are free and always hyaline or light-colored, the *Dematieae* in which the sporophores are free and hyphae and conidia are

dark-colored or black, the *Stilbeae* in which the sporophores are collected into a stipe, and the *Tubercularieae* in which the sporophores are collected in a waxy or gelatinous wart-like head or tuft. The last two groups are very natural ones, and have been retained with some internal alterations. But the two former are often so difficult to distinguish, even by Saccardo's characters, and do such violence to obvious relationships, many times splitting up genera solely because of color, that they cannot be accepted as he has constituted them. So, also, his subdivision of the families according to the septation of the spores does too much violence to plain relationships to be maintainable, even if entirely reliable as a key.

The forms included in the *Mucedineae* and *Dematieae* of Saccardo fall readily into a number of what may be called tribes, based upon the sporophores. These fall into two higher groups, in one of which the sporophore is well developed and usually much-branched, while in the other it is less developed, and either scarcely to be distinguished from the conidia or at most simple and rigid. If objection be made to this arrangement as making it more difficult for one unfamiliar with the genera to place them readily, it may be answered that the latter function belongs not to a systematic arrangement, but to an artificial key or synopsis. The best current dispositions of the larger groups,—such as the Black-fungi, e. g.,—are open to the same objection. For the former of the two groups last mentioned we have retained the name *Mucedinaceae*. For the latter we should have been glad to use the name *Dematiaceae*. But, as *Dematium* cannot be included in the group, we could not well do so.

The nomenclature of families and other groups above genera is not settled. In the absence of rule or authoritative usage to determine such matters, we have employed the first name used to designate a group corresponding to the one in question in some degree, altering the termination to conform to prevailing usage. In the nomenclature of genera and species we have followed the Rochester Rules.

Where forms commonly included in the *Hyphomycetes* have been shown to belong to autonomous groups, we have omitted them, so that the reader will miss *Microstroma*, *Myxotrichum*, *Ceratium*, and many other familiar genera. In the same way we have omitted *Aspergillus* and *Penicillium*. They have a proper place elsewhere, and we see no reason why those forms in which ascus-fructification is yet unknown should not be

placed as a sort of appendix after the perfectly known species in the same manner in which *Aecidium* follows *Puccinia.*

The following scheme will show the groups we propose and their relationship:

SPORODESMIACEAE.

TORULEAE.

CHALAREAE.

RAMULARIEAE.

HELMINTHOSPORIEAE.

DIPLOSPORIEAE. HELICOSPORIEAE.

SPORODESMIEAE.

MYXOTRICHELLEAE.

MUCEDINACEAE.

TRICHOTHECIEAE.

ARTHROBOTRYTEAE.

TRICHODERMEAE.

BOTRYTEAE. VERTICILLIEAE.

PERICONIEAE. POLYACTIDEAE. DEMATIEAE.

STACHYBOTRYTEAE.

CEPHALOSPORIEAE.

STILBACEAE.

STILBEAE.

COREMIEAE. ISARIEAE.

TUBERCULARIACEAE.

TUBERCULARIEAE.

VOLUTELLEAE. FUSARIEAE. CYLINDROCOLLEAE.

Order *HYPHOMYCETEAE.*

Family **SPORODESMIACEAE** (FR.)

Sporodesmiacei FR. Syst. Myc. **3**:489. 1829.

Sporophores free, short and scarcely distinct from the conidia, or if distinct, simple or subsimple, and rigid.

Tribe **Toruleae** (FR.)

Torulei FR. Summ. Veg. Scand. **2**:504. 1849.

Mycelium wanting or but slightly developed, sporophore either entirely wanting or breaking up into chains of conidia, conidia catenulate, not enclosed in a sheath.

Torula and *Alysidium* are quite closely related, perhaps the most substantial difference being in the color. But from this point the group falls readily into two series, the one composed of rigid, coarse, dark-colored forms, the other of more delicate,

light-colored ones. This is one of the few groups in which the distinction between the light-colored and the dark-colored forms may be maintained without necessitating the separation of nearly related forms.

1. **TORULA** PERS. Syn. Fung. 693. 1801 (as a sub-genus). Including *Hormiscium* KUNZE, Sacc. Syl. Fung. **4**: 263. 1886.

Vegetative hyphae decumbent or none; sporophore very short and scarcely distinct from the chains of conidia; conidia uniform black or brown, continuous, oblong, fusoid, globose, or cuboid.

All gradations are met with between species with oblong and fusoid and those with cuboid conidia. Hence it does not seem possible to maintain *Hormiscium* which is only distinguished by its cuboid conidia.

About 30 species are described or reported from the United States.

2. **SPEIRA** CORDA. Ic. Fung. **1**: 9. 1837.

Botryosporium SCHW. Syn. Am. Bor. 306. 1834, not CORDA 1831.
Symphragmidium STRAUSS, Sturm D. C. Fl. III. **34**:41. 1853.

Vegetative hyphae creeping, sparingly branched, subhyaline, or in some species apparently wanting; sporophores very short, making the conidia appear subsessile or short-stipitate; conidia fuliginous, catenulate, in two or more series from each sporophore, the chains at first cohering and producing the appearance of a single muriform-septate spore, but separating at maturity.

5 species are reported from the United States.

3. **DICTYOSPORIUM** CORDA. Ic. Fung. **2**: 87. 1838.

Hyphae none, conidia ovate or subcordate, composed of agglutinated parallel series of septate filaments.

Differs from *Speira* in that the chains of cells do not separate at maturity and in being without a sporophore.

3 species are reported from the United States.

4. **BISPORA** CORDA. Ic. Fung. **1**: 9. 1837.

Sporophores very short; conidia oblong, one-septate, fuscous, catenulate, the chains simple or branched.

3 species are reported from the United States.

5. **SEPTONEMA** Corda. Ic. Fung. **1**: 9 1837.

Vegetative hyphae creeping, often obsolete; sporophores very short and scarcely distinct from the conidia or wanting; conidia oblong, many-septate, brown, catenulate, the chains simple or branched.

As here limited contains 20 species reported from the United States. *Stigmina liriodendri* E. & E. Proc. Acad. Phil. **1893**: 171. 1893, goes here.

6. **SIRODESMIUM** DeNot. Micromyc. It. Decas **5**: 16. 1845.

Vegetative hyphae creeping, few or none; sporophores short or very short so that the chains of conidia are subsessile; conidia ovate-oblong, clathrate-septate, often echinulate, catenulate, constricted more or less at the articulations, the chains simple or branched.

8 species are reported from the United States.

7. **ALTERNARIA** Nees. Syst. **2**: 72. 1816.

Sporophores fasciculate, more or less erect, simple or subsimple, short; conidia clavate flask-shaped, muriform-septate, olivaceous, catenulate. The conidia are connected by narrow isthmus-like contractions which are quite characteristic.

3 species are reported from the United States. They are, like the species of *Macrosporium*, conidial forms of *Pleospora*, chiefly of *P. herbarum*.

Fumago Pers. Myc. Eur. **1**: 9. 1822, must be used instead of *Capnodium* Mont. Ann. Sci. Nat. Bot. III, **11**: 233. 1848, for a genus of *Perisporiaceae*. As almost all the species generally included under this name are stages of various species belonging to the other genus, and the only one reported for North America which is retained by Saccardo (*F. vagans*) is of that sort, a new name is unnecessary.

8. **ALYSIDIUM** Kunze, Myk. Heft. **1**: 18. 1817.

Oospora Wallr. Fl. Crypt. Germ. **2**: 182. 1833. Sacc. Syl. Fung. **4**: 11. 1886.

Cespitose; sporophores short, simple or sparingly branched; conidia concatenate, globose or broadly elliptical, hyaline or light-colored.

Acrosporium Nees. 1816 was founded on *Oidium monilioides* and applied to this group by Persoon in 1822. *Alysidium* was founded for *A. fulvum* Kunze, *Oospora fulva* Sacc. & Vogl. Bonorden, Handb. 35. 1851, took up *Alysidium* and described

several species, one a *Torula*, but the rest included in *Oospora* by Saccardo. There would seem to be no reason why *Alysidium* should not be preferred even by those who would restrict the rule of priority by a year-limitation.

The species reported from the United States to be included in the genus as here limited are:

ALYSIDIUM ALBIPES (PK.)
Oidium albipes PK. Rep. N. Y. Mus. **30**:—(57). 1878.

ALYSIDIUM CANDIDULUM (SACC.)
Oospora candidula SACC. Mich. **2**: 545. 1882.

ALYSIDIUM COMPACTUM (C. & E.)
Oidium compactum C. & E. Grev. **6**: 5. 1877.

ALYSIDIUM CUBOIDEUM (SACC. & ELL.)
Oospora cuboidea SACC. & ELL. Mich. **2**: 576. 1882.

ALYSIDIUM CUCUMERIS (PK.)
Oospora cucumeris PK. Rep. N. Y. Mus. **41**:—(80). 1888

ALYSIDIUM FASCICULATUM (GREV.) Pound & Clements Bot. Surv. Nebr. **4**: 37. 1896.
Acrosporium fasciculatum GREV. Fl. Ed. 469. 1824.
Oidium fasciculatum BERK. Smith's Engl. Fl. **5**: 349. 1836.
Oospora fasciculata SACC. & VOGL. Syl. Fung. **4**: 11. 1886.

ALYSIDIUM FULVUM KUNZE, Myk. Heft. **1**: 18. 1817.

ALYSIDIUM HYALINULUM (SACC.)
Torula hyalinula SACC. Mich. **1**: 538. 1879.
Oospora hyalinula SACC. Mich. **2**: 453. 1882.

ALYSIDIUM INSULARE (THUEM.)
Torula insularis THUEM. Flora **61**:—(6). 1878.

ALYSIDIUM LACTIS (FRES.)
Oidium lactis FRES. Beitraege 23. *Pl. 3 f. 41.* 1850.

ALYSIDIUM OVALISPORUM (BERK.)
Torula ovalispora BERK. Smith's Engl. Fl. **5**: 359. 1836.

ALYSIDIUM PALLIDUM (B. & RAV.)
Torula pallida B. & RAV. Grev. **3**: 14. 1873.

ALYSIDIUM PULVINATUM (B. & C.)
Oidium pulvinatum B. & C. Grev. **3**: 112. 1875.

ALYSIDIUM TULIPIFERAE (E. & M.)
Oospora tulipiferae E. & M. Am. Nat. **16**: 1004. 1882.

9. **FUSIDIUM** LK. Obs. **1**: 6. 1809.

Sporophores short, simple; conidia fusiform, concatenate, hyaline or light-colored.

2 species are reported from the United States.

10. **CYLINDRIUM** BON. Handb. Alg. Myk. 34. 1851.

Mycelium scanty or none; sporophores very short, scarcely or not at all distinct from the conidia; conidia long-cylindrical, obtuse at the ends, concatenate, the chains of conidia simple or branched, hyaline or light-colored.

2 species are reported from the United States.

11. **SEPTOCYLINDRIUM** Bon. Handb. Alg. Myk. 34. 1851.

Sporophores very short and scarcely distinct from the conidia, or in parasitic species distinct but short and inflated or denticulately sub-lobate at the apex; conidia oblong or cylindrical, one to many-septate, concatenate, the chains often branched.

We have followed Dr. Halsted in including in this genus the species of *Ramularia* with short simple sporophores and chains of conidia, usually branched.

As here limited, contains 14 species reported from the United States. Of the saprophytic species the type is:

Septocylindrium septatum (Bon.) Pound Am. Nat. **23**: 163. 1889.
Cylindrium septatum Bon. Handb. Alg. Myk. 35. 1851.
Septocylindrium bonordenii Sacc. Mich. **2**: 15. 1880.

The parasitic species, including those brought over from *Ramularia*, are:

Septocylindrium areola (Atkinson).
Ramularia areola Atkinson. Bot. Gaz. **15**: 168. 1890.

Septocylindrium canadense (E. & E.)
Ramularia canadensis E. & E. Proc. Acad. Phil. **1891**: 84. 1891.

Septocylindrium concomitans (Ell. & Holw.) Halsted, Seymour & Earle E c. Fung. No. 299. 1893.
Ramularia concomitans Ell. & Holw. Journ. Myc. **4**: 2. 1888.

Septocylindrium euonymi (E. & K.)
Ramularia euonymi E. & K. Journ. Myc. **1**: 3. 1885.

Septocylindrium ranunculi Pk. Rep. N. Y. Mus. **34**:--(46). 1883.

Septocylindrium repens (E. & E.)
Ramularia repens E. & E. Proc. Acad. Phil. **1891**: 85. 1891.

Septocylindrium rufo-maculans (Pk.)
Ramularia rufo-maculans Pk. Rep. N. Y. Mus. **34**:—(46). 1883.

Septocylindrium scirpinum Pk. Rep. N. Y. Mus. **45**:—(93). 1893.

Septocylindrium spiraeae (Pk.)
Ramularia spiraeae Pk. Rep. N. Y. Mus. **34**:—(46). 1883.

Ellis and Everhart (Journ. Myc. **1**: 79) include this under *Ramularia ulmariae* Cke., but in the absence of further data we retain the name *spiraeae*. *R. ulmariae* seems a true *Ramularia*

Septocylindrium stoloniferum (E. & E.)
Ramularia stolonifera E. & E. Proc. Acad. Phil. **1891**: 85. 1891.

Septocylindrium subrufum (Ell. & Holw.)
Ramularia subrufa Ell. & Holw. Journ. Myc. **4**: 2. 1888.

12. **POLYSCYTALUM** Riess, Bot. Zeit. **11**: 138. 1853.

Sporophore rigid, simple or slightly branched, hyaline or fuliginous; conidia cylindrical, truncate at both ends, concatenate, resembling joints of the sporophores.

2 species are reported from the United States.

13. **HELICOCEPHALUM** Thaxt. Bot. Gaz. **16**:201. 1891.

Vegetative hyphae small, creeping over the substratum; sporophores erect, simple, continuous, spirally coiled at the apex, the spiral portions becoming septate and constricted at intervals, forming at maturity a chain of large, dark-colored, thick-walled spores.

Contains but one species.

14. **MONILIA** Pers. Tent. Disp. Meth. Fung 40. 1797.

Sporophores erect, septate, irregularly branched, here and there minutely denticulate, each projection giving rise to a chain of conidia; conidia globose, elliptical, or lemon-shaped.

The sporophores are long and well developed, and in some species at first appear to attain such size as to distinguish them from the rest of the *Toruleae*. But the hyphae break up into long chains of conidia at maturity, and in many other species the sporophore is not to be distinguished from a much branched chain of conidia. Between these types all gradations are to be found, even in the same species.

Like *Alysidium*, a somewhat heterogeneous group. The parasitic forms belong to *Sclerotinia*.

15 species are reported from the United States.

Oospora similis Sacc. is the same as *Monilia aureo-fulva* C.& E., which must become:

Monilia similis (Berk.)
Oidium simile Berk. Lond. Journ. Bot. **4**:310. *Pl. 12 f. 4.* 1845.
Monilia aureo-fulva C. & E. Grev. **8**:12. 1886.

Oidium Lk., as now limited, contains nothing but conidial stages of *Erysipheae*. Most of the species are now well enough known in all stages, and it does not seem necessary to burden this group with them longer.

Tribe **Chalareae** Sacc. Syl. Fung. **4**:33. 1886.
Including *Sporoschismeae* Sacc. Syl. Fung. **4**:486. 1886.

Sporophore erect, simple, scarcely distinct from the conidia, hyaline or fuscous, surrounded by a sheath; conidia catenulate, continuous or septate, hyaline or fuscous.

15. **CHALARA** Corda. Ic. Fung. **2**:9. 1838.

Sporophore simple, erect, hyaline; sheath more or less swollen, fuscous; conidia continuous, cylindrical, truncate, hyaline.

5 species are reported from the United States.

16. **SPOROSCHISMA** B. & Br. Gard. Chron. **1847**: 540. 1847.

Sporophore simple, erect, fuscous; sheath cylindrical, fuscous; conidia many-septate, oblong-cylindrical, fuscous.

Contains one species.

17. **SPORENDONEMA** Desm. Ann. Sci. Nat. Bot. I. **11**: 246. 1827.

Vegetative hyphae creeping; sporophores erect; conidia formed within the sporophores and pushing out in chains, hyaline, becoming fuscous, globose or ellipsoid, continous.

Sporendonema casei Desm. is an *Alysidium.* The genus as now limited, was defined by Oudemans, Ver. Acad. Amsterd. **1885**: 115.

1 species is described from the United States.

Tribe **Ramularieae** Sacc. Syl. Fung. **4**: 196. 1886.

Parasites; sporophores distinct from the conidia, attaining some length, simple or sub-simple; conidia solitary, or in *Ramularia* sometimes sub-catenulate, acrogenous or acro-pleurogenous on flexuose or nodulose sporophores.

18. **OVULARIA** Sacc. Mich. **2**: 17. 1880.

Sporophores erect, hyaline, sometimes slightly branched, nodulose or subdenticulate towards the apex, or entire; conidia globose or ovoid, continuous, hyaline, acro-pleurogenous or in some species acrogenous, sometimes sub-catenulate.

Massee has removed to this genus all of the species of *Ramularia* with continuous spores, as a consistent following of Saccardo's arrangement requires. We have preferred to limit it to those species with ovoid spores, though inclined to think it still better to unite *Ovularia* and *Didymaria* with *Ramularia.*

As here limited, contains 9 species reported from the United States. The most common is:

Ovularia monosporia (West.)
Oidium monosporium West. Bull. Soc. Roy. Bot. Belg. **2**: 252. 1863.
Peronospora obliqua Cooke. Micr. Fung. 160. 1865.
Ramularia obovata Fkl. Symb. Myc. 103. 1869.
Ovularia obovata Sacc. Fung. Ital. 972. 1881.
Ovularia obliqua Oud. Hedw. **22**: 85. 1883.

19. **HADOTRICHUM** Fkl. Symb. Myc. 221. 1869.

Sporophores short, simple, rather thick and stout or in some species sub-nodulose or flexuose, fuscous, fasciculate at the base; conidia black or fuscous, continuous, globose, elliptical, or ovoid, solitary acrogenous.

4 species are reported from the United States. Some of the species are conidial forms of *Scirrhia.*

20. **DIDYMARIA** CORDA. Ic. Fung. **6**:8. 1854.

Sporophores simple or sub-simple, fasciculate, hyaline; conidia acrogenous or acro-pleurogenous on nodulose sporophores, hyaline, elliptical-ovate or broad-oblong, one-septate.

4 species reported from the United States. The type is:

DIDYMARIA DIDYMA (UNGER) POUND. Am. Nat. **23**:163. 1889.
Ramularia didyma UNGER Exanth. 169. 1833.
Didymaria ungeri CORDA Anleit. *Pl. B. f. 9, 1.* 1842.

Bostrichonema CES., with simple, erect, spirally flexuous sporophores, belongs here. No species are reported for this country.

21. **RAMULARIA** UNGER. Exanth. 169. 1833.

Sporophores fasciculate, simple or with short, scattered branchlets, often flexuous, nodulose, or denticulate towards the apex, hyaline or light colored; conidia acrogenous or acro-pleurogenous on the denticulations, hyaline, sometimes sub-catenulate, oblong-cylindrical, typically many-septate, sometimes one-septate or continuous.

Ovularia and *Didymaria* are separated from this genus by the shape of the spores. All three, as well as *Cercospora* are made up of conidial forms of *Sphaerella.*

About 60 species are reported for the United States.

22. **CERCOSPORA** FRES. Beitraege 90. 1863.

Virgasporium CKE. Grev. **3**:182. 1875.
Cercosporella SACC. Mich. **2**:20. 1880.

Sporophores fasciculate, simple, or sometimes sparingly branched, typically fuliginous, but in the sub-genus *Cercosporella* hyaline, flexuous and nodulose or denticulate towards the apex; conidia acrogenous or pleurogenous from tooth-like projections below the apex of the sporophore, pale fuliginous or hyaline, vermiform or elongated cylindrical, usually attenuate above, many-septate.

Cercospora is closely allied to *Ramularia*, but is well distinguished by the shape of the conidia. The conidia are also much longer than in *Ramularia*. Some species might well be placed in either genus. Including *Cercosporella*, about 400 species are reported from this country, and more are being described continually. Among the species which we think should be transferred from *Ramularia* to *Cercospora* is *R. virgaureae* THUEM. Journ. Myc. **1**:80. 1885. This would become *Cercospora virgaureae* (THUEM.) E. & E. Journ. Myc. **5**:69. 1889.

23. **SCOLECOTRICHUM** KUNZE & SCHM. Myk. Heft. **1**:10. 1817.

Sporophores short, simple, subfasciculate, olivaceous or fuliginous, nodulose; conidia oblong or ovate, pleurogenous and acrogenous, olivaceous or green, one-septate.

Resembles *Ramularia* in the sporophores and shape of the conidia, but is well distinguished by the color. Differs from *Passalora* in the pleurogenous conidia.

3 species are reported from the United States.

24. **PASSALORA** FRIES. Summ. Veg. Scand. 500. 1849.

Fusicladium BON. Handb. Alg. Myk. 80. 1851.

Sporophores simple, subfasciculate, variable in length; conidia acrogenous, oblong, ovoid, subfusoid or subclavate, olivaceous or fuliginous, one-septate.

While in typical forms *Passalora* and *Fusicladium* may be distinguished by the long, filiform, septate sporophores of the former, and the short, straight, continuous sporophores of the latter, a large number of forms, ascribed to *Fusicladium*, with long, septate sporophores render it difficult and useless to maintain the distinction.

About 12 species are reported from the United States, including *Fusicladium.*

Polythrincium KZE. & SCHM. Myk. Heft. **1**:13. 1817, has only one species, the conidial stage of *Phyllachora trifolii.* The sporophores are black, fasciculate, short and thick, and regularly flexuose or torulose, and the conidia are acrogenous and one-septate.

25. **NAPICLADIUM** THUEM. Hedw. **14**:3. 1875.

Sporophores fasciculate, short but not rigid, olivaceous or brown; conidia acrogenous, rather large, oblong, many-septate, dark colored or hyaline.

Differs from *Passalora* in having many-septate conidia. 2 species are reported from the United States.

26. **PIRICULARIA** SACC. Mich. **2**:20. 1880.

Sporophores erect, simple or sub-simple, rather long, grayish or hyaline; conidia acrogenous, obclavate pyriform, 2—many-septate.

Our common species and the one other described from this country seem to be connected with *Phyllachora graminis.*

Tribe **Helminthosporieae** (CORDA).

Helminthosporiacei CORDA. Anleit. 1839.

Vegetative hyphae creeping or obsolete; sporophores erect or ascending, elongated, typically much longer than the conidia; simple or branched, scarcely acervulate, hyaline or fuscous; conidia single, rarely catenulate, solitary, hyaline or fuscous, acrogenous or pleurogenous.

Most of the genera contain both saprogenous and phyllogenous species. The genera are very hard to limit satisfactorily, though well marked in typical forms, and many species need to be transferred. The group is one of the most difficult among the Imperfect Fungi.

27. **CLADOSPORIUM** LK. Obs. **2**:37. 1813.

Sporophores erect or ascending, branched, elongated, fuscous; conidia single, sometimes catenulate, acrogenous or acro-pleurogenous, oblong or ovoid to globose, fuscous, typically one-septate, rarely 2–3-septate.

Many of the species need further examination. About 50 are reported for the United States.

28. **HETEROSPORIUM** KLOTSCH. Herb. Myc. **1**: No. 27 1832.

Sporophores erect or ascending, sub-acervulate, simple or ramulose, short, fuscous; conidia single, very rarely catenulate, acrogenous or acro-pleurogenous, oblong, echinulate or verrucose, many-septate.

Well distinguished by the echinulate or verrucose conidia.

18 species are reported from the United States. *Brachysporium sarraceniae* MacMillan Bull. Torr. Bot. Club **18**:214. 1891, having echinulate conidia, must be placed here.

29. **HELMINTHOSPORIUM** LK. Obs. **1**:10. 1809.

Including *Brachysporium* SACC. Mich. **2**:28. 1880.

Vegetative hyphae obsolete; sporophores erect or ascending, often branched, elongated, septate, fuscous; conidia single, acrogenous or acro-pleurogenous, smooth, cylindrical to ovoid, many-septate.

As here limited, contains 70 species reported from this country. The following changes are required by our limitation of the genus:

HELMINTHOSPORIUM CANADENSE (E. & E.)
Brachysporium canadense E. & E. Journ. Myc. **7**: 134. 1892.

HELMINTHOSPORIUM PEDUNCULATUM (PECK).
Clasterosporium pedunculatum PECK. Rep. N. Y. Mus. **23**:—(93). 1873.
Helminthosporium attenuatum C. & P. Rep. N. Y. Mus. **29**:—(50). 1878.

Brachysporium gracile SACC. Syl. Fung. **4**: 430. 1886, is the same as *Heterosporium gracile* SACC. Syl. Fung. **4**: 480. 1886.

30. **STEMPHLYIUM** Wallr. Flor. Crypt. Germ. **2**: 300. 1833.

Vegetative hyphae intricate, creeping; sporophores ascending, irregularly branched, elongated, hyaline or fuscous; conidia single, acrogenous, typically smooth, fuscous, globose to ovoid, muriform-septate.

6 species are reported from North America.

31. **MACROSPORIUM** Fr. Syst. Myc. **3**: 373. 1832.

Including *Mystrosporium* Corda. Ic. Fung. **1**: 12. 1837.

Vegetative hyphae obsolete; sporophores erect or ascending, simple or sub-ramose, elongate, fuscous; conidia single, acrogenous, sometimes acro-pleurogenous, fuscous, oblong to clavate, muriform-septate.

Including *Mystrosporium*, about 80 species are reported from this country. The larger part of them belongs to *Pleospora herbarum*.

The following changes are necessitated by our limitation of the genus:

Macrosporium aterrimum (B. & C.)
Mystrosporium aterrimum B. & C. Cooke Black Moulds *Pl. 26 f. 18.* 1877.

Macrosporium curtisii (Berk.)
Mystrosporium curtisii Berk. Grev. **3**: 105. 1875.
Mystrosporium spraguei Cooke. Black Moulds. *Pl. 26 f 17.* 1877.

Macrosporium erectum (E. & E.)
Mystrosporium erectum E. & E. Journ. Myc. **4**: 53. 1888.

Macrosporium melanosporum (B. & C.)
Helminthosporium melanosporum B. & C. Grev. **3**: 104. 1875.
Mystrosporium melanosporum Sacc. Syl. Fung. **4**: 540. 1886.

Macrosporium orbiculare (C. & E.)
Mystrosporium orbiculare C. & E. Grev. **7**: 40. 1878.

Macrosporium turbinatum (Cke. & Harkn.)
Mystrosporium turbinatum Cke. & Harkn. Grev. **12**: 95. 1884.

32. **TRICHAEGUM** Corda. Ic. Fung. **1**: 15. 1837.

Vegetative hyphae obsolescent; sporophores erect, subsimple, septate, acervulate, fuscous; conidia pleurogenous near the base of the sporophore, conglobate, muriform-septate, often asperate, globose to elliptical, fuscous.

4 species reported from the United States.

33. **TRIPOSPORIUM** Corda. Ic. Fung. **1**: 16. 1837.

Vegetative hyphae little developed; sporophore erect, simple or subramose, septate, fuscous; conidia acrogenous, staurosporous, fuscous.

2 species reported from the United States.

34. **CAMPOSPORIUM** HARKN. Bull. Cal. Acad. Sci. **1**:—(17). 1884.

Vegetative hyphae obsolete; sporophores simple, erect, fuscous; conidia acrogenous, solitary or in twos, pedicillate, 1—3-ciliate at the apex, many-septate, cylindrical, fuscous.

One species described.

Blodgettia WRIGHT. Trans. Ir. Acad. **28**:25. 1881, is so evidently a *Phycomycete*, that it seems improper to include it.

Tribe **Helicosporieae** (SACC.)

Mucedineae Helicosporeae and *Dematieae Helicosporeae* SACC. Syl. Fung. **4**:233 and 557. 1886.

Vegetative hyphae present or obsolete; sporophore erect or ascending, more rarely procumbent, typically micronemeous, simple or branched, hyaline or fuscous; conidia elongate, more or less filiform, uncinately curled or spirally coiled, many-septate or at least guttulate, hyaline or fuscous.

The *Helicosporieae* of North America have recently been monographed by Morgan, whose arrangement is followed. The separation of the hyaline from the dark-colored forms, required by the Saccardian arrangement which puts them in different families, makes some change in generic limitation necessary in a grouping in which that arbitrary distinction is not made use of.

35. **HELICOMYCES** LK. Obs. Myc. **1**:19. 1809.

Helicosporium NEES. Syst. 68. 1816.
Helicopsis KARST. Rev. Myc. **11**:96. 1889.

Vegetative hyphae present or obsolescent; sporophores short or elongate, more or less branched, hyaline or fuscous; conidia elongate-filiform or linear, loosely uncinate-convolute, hygroscopic, hyaline or fuscous.

Contains 18 species reported from the United States. The following species reported from this country, not transferred to this genus by Morgan, should be included:

HELICOMYCES BRUNNEOLUS (B. & C.)
Helicosporium brunneolum B. & C. Grev. **3**:51. 1874.

HELICOMYCES CURTISII (BERK.)
Helicoma curtisii BERK. Grev. **3**:106. 1875.
Helicosporium curtisii SACC. Syl. Fung. **4**:560. 1886.

HELICOMYCES DIPLOSPORUS (E. & E.)
Helicosporium diplosporum E. & E. Proc. Acad. Phil. **1891**:93. 1891.

HELICOMYCES FASCICULATUS (B. & C.)
Helicoma fasciculatum B. & C. Proc. Am. Acad. Arts & Sci **4**:118. 1858.
Helicosporium fasciculatum SACC Syl. Fung. **4**:560. 1886.

HELICOMYCES LEPTOSPORUS (SACC.)
Helicosporium leptosporum SACC. Syl. Fung. **4**:559. 1886.
Helicosporium griseum B. & C. Grev. **3**:51. 1874, not BON. 1851.

HELICOMYCES MICROSCOPICUS (ELL.)
Helicosporium microscopicum ELL. Bull. Torr. Bot. Club. **9**:98. 1882.

HELICOMYCES MUELLERI (CORDA).
Helicoma muelleri CORDA. Ic. Fung. **1**:15. *Pl. 4. f. 219.* 1837.
Helicosporium muelleri SACC. Mich. **2**:129. 1880.

HELICOMYCES VEGETUS (NEES.)
Helicosporium vegetum NEES. Syst. 68. *f. 69.* 1816.

36. **HELICOMA** CORDA. Ic. Fung. **1**:15. 1837.

Vegetative hyphae creeping; sporophores short, ascending, subsimple, hyaline or fuscous; conidia thick, rigid, elongate-oblong or linear, closely and firmly uncinate convolute, hyaline or fuscous, not hygroscopic.

9 species are reported from this country.

37. **HELICOON** MORG. N. Am. Helicosporae, 49. 1894.

Vegetative hyphae present or obsolete; sporophore short and erect or obsolescent, septate, hyaline or fuscous; conidia elongate-filamentous, coiled into a conic-elliptical body, hyaline or fuscous.

4 species reported.

Tribe **Diplosporieae.**

Sporophores erect, rigid, more or less inflated at the joints, branched; conidia acrogenous on the ends of the branchlets, catenulate.

38. **DIPLOSPORIUM** LK. Sp. Pl. **1**:64. 1824.

Cladotrichum CORDA. Sturm Deutschl. Fl. III. **3**:39. 1837.

Vegetative hyphae creeping; sporophores erect, black, somewhat rigid, more or less inflated at the joints, branched; conidia acrogenous, short catenulate, or apparently single, one-septate, fuscous.

3 species are reported from the United States.

Tribe **Sporodesmieae** (FR.)

Sporodesmiei FR. Summ. Veg. Scand. **2**:505. 1849.

Vegetative hyphae obsolescent or obsolete; sporophores erect, micronemeous, typically simple, much shorter than the conidia or at most scarcely equalling them, often unicellular, sometimes even entirely obsolete, usually forming more or less distinct capitula, hyaline or fuscous; conidia single, i. e., never catenulate, solitary, acrogenous, rarely acro-pleurogenous, hyaline or fuscous, continuous or septate.

39. **CONIOSPORIUM** Lk. Obs. Myc. **1**:8. 1809.

Chromosporium Corda, Sturm. Deutschl. Crypt. Fl. iii. **9**:119. 1829.

Gymnosporium Corda, Sturm. Deutschl. Crypt. Fl. iii. **13**:69. 1833.

Papulina Fr. Summ. Veg. Scand. **2**:509. 1849.

Sporophore obsolescent or altogether wanting; conidia simple, hyaline or fuscous, inappendiculate, globose to oblong.

Chromosporium, differing only in color, has been included. 21 species contained in the genus thus limited are reported from the United States. The following are transferred from *Chromosporium:*

Coniosporium fulvum (B. & C.)
Gymnosporium fulvum B. & C. Journ. Linn. Soc. **10**:355. 1869.
Chromosporium fulvum Sacc. Syl. Fung. **4**:6. 1886.

Coniosporium lateritium (Cke. & Harkn.)
Chromosporium lateritium Cke. & Harkn. Grev. **12**:94. 1884.
Chromosporium cookei Sacc. Syl. Fung. **4**:7. 1886.

Coniosporium pactolinum (Cke. & Harkn.)
Corticium pactolinum Cke. & Harkn. Grev. **9**:81. 1881.
Chromosporium pactolinum Cke. Grev. **16**:72. 1888.

Coniosporium vitellinum (Sacc. & Ell.)
Chromosporium vitellinum Sacc. & Ell. Misc. Myc. **2**:18. 1884.

40. **DICOCCUM** Corda. Sturm. Deutschl. Crypt. Fl. iii. **9**: 117. 1829.

Vegetative hyphae obsolete; sporophores short, obsolescent; conidia one-septate, hyaline or fuscous, inappendiculate, oblong to clavate.

3 species are described from the United States.

41. **CERATOPHORUM** Sacc. Mich. **2**:22. 1880.

Vegetative hyphae creeping, obsolescent; sporophores short, erect; conidia 2—several-septate, fuscous, appendiculate, fusoid to cylindrical.

42. **TETRAPLOA** B. & Br. Ann. Mag. N. H. No. 547.

Sporophores obsolete; conidia muriform-septate, fuliginous, pluri-corniculate at the apex, ovate-oblong.

2 species are reported from this country.

43. **CLASTEROSPORIUM** Schw. Syn. Fung. Am. Bor. 300. 1834.

Vegetative hyphae creeping, ramose, fuscous; sporophore obsolete; conidia erect or ascending, solitary, short-pedicelled, many-septate, inappendiculate, fuscous, fusoid to cylindrical· saprogenous.

Contains 14 species reported from the United States, as here limited.

Clasterosporium olivaceum E. & E. Proc. Acad. Phil. **1893**: 463. 1893, not *C. olivaceum* (WALLR.) SACC. Syl. Fung. **4**:390. 1886, must be altered. We suggest the name *Clasterosporium elaeodes.*

44. **CERATOSPORIUM** SCHW. Syn. Fung. Am. Bor. 300. 1834.

Vegetative hyphae creeping or obsolescent; sporophores obsolete; conidia many-septate, hyaline or fuscous, digitately fasciculate, more or less united at the base, clavate cylindrical.

1 species is reported from the United States.

45. **SEPTOSPORIUM** CORDA. Sturm. Deutsch. Crypt. Flor. III. **12**: 33. 1831.

Vegetative hyphae obsolete; sterile hyphae simple, elongate, fuscous, erect, intermingled with the sporophores; sporophores short, simple, pedicel-like, concolorous; conidia muriform-septate, fuscous, ovate to limoniform.

7 species are reported from this country.

46. **STIGMINA** SACC. Mich. **2**: 22. 1880.

Vegetative hyphae obsolete; sporophore simple, short, 1—2 celled, often reduced to a mere pedicel or rarely wanting; conidia acervulate or discrete, erect, many-septate, inappendiculate, ovoid, elliptical-oblong, or fusoid; saprogenous or phyllogenous.

As here limited, contains 10 species reported from the United States. Several species described under *Sporodesmium* and placed in *Clasterosporium* by Saccardo are to be placed here:

STIGMINA ATRA (LK.)
Sporodesmium atrum LK. Obs. Myc. **1**: 39. 1809.
Clasterosporium atrum SACC. Syl. Fung. **4**: 386. 1886.

STIGMINA CAESPITULOSA (E. & E.)
Clasterosporium caespitulosum E. & E. Journ. Myc. **5**: 70. 1889.

STIGMINA CAPSULARUM (THUEM.)
Sporidesmium capsularum THUEM. Flora **61**: 177. 1878.
Clasterosporium capsularum SACC. Syl. Fung. **4**: 388. 1886.

STIGMINA CLAVULATA (CKE. & HARKN.)
Bactrodesmium clavulatum CKE. & HARKN. Grev. **12**: 95. 1884.
Clasterosporium clavulatum SACC. Syl. Fung. **4**: 390. 1886.

STIGMINA LARVATA (C. & E.)
Sporidesmium larvatum C. & E. Grev. **6**: 86. *Pl. 99. f. 12.* 1878.
Clasterosporium larvatum SACC. Syl. Fung. **4**: 385. 1886.

STIGMINA MACLURAE (THUEM.)
Sporidesmium maclurae THUEM. Mycotheca Universalis No. 2074. 1881.
Clasterosporium maclurae POUND. Rep. Nebr. St. Board Agr. **1889**: 223. 1890.

STIGMINA OBCLAVATA (CKE.)
Sporidesmium obclavatum CKE. Grev. **6**: 137. 1878.
Clasterosporium obclavatum SACC. Syl. Fung. **4**: 386. 1886.

STIGMINA POPULI (E. & E.)
Clasterosporium populi E. & E. Journ, Myc. **7**: 134. 1892.

STIGMINA STICTICA (B. & C.)
Sporidesmium sticticum B. & C. Grev. **3**: 50. 1874.
Clasterosporium sticticum SACC. Syl. Fung. **4**: 388. 1886.

47. **SPORODESMIUM** LK Obs. Myc. **1**: 39. 1809.

Including *Stigmella* LEV. Demidoff. Voy. 111. 1842.

Vegetative hyphae obsolete; sporophore simple, 1—2 celled, pedicel-like; conidia discrete or acervulate, muriform or clathrate-septate inappendiculate, fuliginous or fuscous, ovate to oblong; saprogenous or phyllogenous.

We have placed in *Stigmina* all forms which would belong here but for the septation of the spores. This restores the original limitation of *Clasterosporium*, but restricts *Sporodesmium* to species with muriform-septate conidia, as limited by Saccardo.

43 species are reported from the United States. The following changes are required by our arrangement, or for other reasons.

SPORODESMIUM BICOLOR (PK.)
Septonema bicolor PK. Rep. N. Y. Mus. **28**:—(60.) 1876.
Sporodesmium peziza C. & E. Grev. **4**: 178. 1876.

SPORODESMIUM PITHYOPHILA (CKE.)
Stigmella pithyophila CKE. Grev. **16**: 71. 1888.

SPORODESMIUM VERSISPORUM POUND & CLEMENTS.
Sporodesmium toruloides E. & E. Proc. Roch. Acad. Sci. **1**: 51. 1890, not FRIES, nor COOKE.

48. **CONIOTHECIUM** CORDA. Ic Fung. **1**: 2. 1837.

Vegetative hyphae and sporophores obsolete; conidia acervulate, inappendiculate, fuscous, muriform-sarcinate, cruciate, or radiate, irregularly globose or oblong; saprogenous or phyllogenous.

4 species are reported from the United States. We make one change:

CONIOTHECIUM SARCOSPORIOIDES (ELL. & ANDER.)
Sporodesmium sarcosporioides ELL. & ANDER. Bot. Gaz. **16**: 47. *Pl. 10 f. 8-10.* 1891.

Myxotrichum KZE. is one of the *Gymnoasceae* and should not be kept with the Imperfect Fungi. For those forms which are properly Imperfect Fungi Saccardo has proposed the name *Myxotrichella*. *Myxotrichella* is somewhat anomalous, and would have to be placed in a tribe by itself, which might be called *Myxotrichelleae*.

Ellisiella SACC. which would be placed in the family *Sporodesmiaceae* if retained, and would doubtless require a tribe by itself, does not seem sufficiently distinct from *Colletotrichum* in the *Melanconieae.*

Family **MUCEDINACEAE** (LK.)

Mucedines LK. Berl. Mag. **3**:10. 1809. (Obs. Myc. **1**: 10.)

Sporophores entirely distinct from the conidia, well developed, typically long and much branched.

Tribe **Trichothecieae.**

Vegetative hyphae creeping or obsolescent; sporophores erect, simple, hyaline or fuscous; conidia acrogenous, solitary or clustered, 1—several septate, hyaline, the diameter much greater than that of the sporophore; saprogenous.

1. **TRICHOTHECIUM** LK. Obs. **1**: 16. 1809.

Sporophores erect, simple, hyaline; conidia solitary, 1-septate, hyaline or bright-colored, ovate to ellipsoid.

4 species are reported from the United States.

2 **DACTYLELLA** GROVE. Journ. Bot. **22**: 199. 1884.

Sporophores erect, simple, hyaline; conidia solitary, 2—many-septate, hyaline, fusoid to cylindrical.

D. ellipsospora (PREUSS) GROVE has recently been reported.

3. **DACTYLARIA** SACC. Mich. **2**: 20. 1880.

Sporophores erect, simple, hyaline; conidia acrogenous, clustered, 2—many-septate, hyaline, clavate to cylindrical.

2 species are reported from the United States.

4. **CORDANA** PREUSS. Linn. **24**: 129. 1851, not SACC. Syl. Fung. **4**: 195. 1886.

Acrothecium PREUSS. Linn. **24**: 129. 1851, not CORDA.

Sporophores erect, simple, fuscous; conida acrogenous, clustered, 2—many-septate, sub-hyaline or fuscous, oblong to cylindrical.

3 species are reported from this country.

Tribe **Arthrobotrytae** CORDA. Prachtfl. 43. 1839.

Gonatobotryteae SACC. Syl. Fung. **4**: 168. 1886.

Vegetative hyphae creeping; sporophores erect, typically simple; conidia borne upon the more or less swollen, denticulate nodes and usually also upon an apical swelling, simple, clustered, hyaline or fuscous.

5. **GONATOBOTRYUM** SACC. Mich. **2**: 24. 1880.

Sporophores simple, erect, fuscous, nodose-inflated; conidia clustered, ovoid to elliptical, fuscous.

1 species is reported from this country.

6. **ARTHROBOTRYS** CORDA. Prachtfl. 43. 1839.

Sporophores erect, simple, hyaline, nodose-inflated, the nodes verrucose; conida 1-septate, hyaline, ovoid.

1 species reported.

7. **SPONDYLOCLADIUM** MART. Flor. Crypt. Erlang. 355. 1817.

Sporophores erect, simple, rigid, fuscous; conidia 1—many-septate, verticillate-clustered at the septa of the sporophore, fuscous, clavate-fusoid.

Gonatorrhodiella THAXT. Bot. Gaz. **16**: 202. 1891, in its mode of conidia-formation closely resembles *Gonatorrhodum*, a European genus which is to be placed here. We know *Gonatorrhodiella* only from Dr. Thaxter's figure and description. Judging from them, we cannot forbear to think that the genus is related to *Aspergillus* and its allies, and that its resemblance to the forms here in question arises from proliferation of the vesiculae.

Tribe **Trichodermeae** FRIES. Syst. Myc. **3**:203. 1829.

Sporophores erect, irregularly branched, hyaline or light-colored; conidia single, acrogenous, simple or one-septate.

8. **TRICHODERMA** PERS. Tent. Disp. Meth. Fung. 12. 1797.

Vegetative hyphae decumbent, forming loosely compacted, plane cespituli; sporophores erect, loosely branched, commonly dichotomous or trichotomous; conidia acrogenous, globose, single, forming small heads.

T. lignorum, the type is the conidial stage of *Hypocrea rufa*. The other so-called species are doubtful, most of them having been insufficiently characterized by the older mycologists.

9. **JACOBASCHELLA** O. KUNTZE. Rev. Gen Pl. **1**:280. 1891.

Diplosporium BON. Handb. 98. 1851, not LK.

Vegetative hyphae creeping; sporophores erect, irregularly branched; conidia solitary acrogenous, one-septate, ovoid or oblong.

1 species is reported from the United States. *Jacobaschella brevis* (PK.), *Diplosporium breve* PK. Rep. N. Y. Mus. **44**:—(26). 1893.

Fusiporium Lk., now generally included in *Fusarium*, if kept separate, should be placed here. The propriety of the present disposition of *Fusiporium* is discussed under *Fusarium.*

Tribe **Verticillieae** Sacc. Syl. Fung. **4**: 149. 1886.

Sporophores erect or ascending, verticillately branched, or the ultimate branches verticillately disposed or at least dichotomous, hyaline or fuscous; conidia acrogenous, solitary, rarely capitate, never catenulate, simple or septate, hyaline or fuscous.

10. **VERTICILLIUM** Nees. Syst. Pilz. 57. 1816.

Sporophores oppositely or verticillately branched or the ultimate branches verticillate, hyaline or bright colored; conidia solitary, simple, concolorous.

18 species are reported from the United States. The species are conidial stages of *Hypocreaceae*, e. g. *Hypomyces.*

11. **VERTICICLADIUM** Preuss. Linn. **24**: 127. 1851.

Sporophores oppositely or verticillately branched, fuscous; conidia solitary, simple, hyaline or fuscous.

2 species are reported from the United States.

12. **DIPLOCLADIUM** Bon. Handb. Alg. Myk. 98. 1851.

Sporophores verticillately branched; conidia typically solitary, one-septate, hyaline.

1 species reported from the United States. Like *Verticillium* contains conidial forms of *Hypomyces.*

13. **DACTYLIUM** Nees. Syst. Pilz. 58. 1816.

Sporophores verticillately branched, rarely simply verticillate; conidia solitary, 2—many-septate, hyaline.

2 species are reported from this country. The genus contains conidial stages of *Hypocreaceae (Hypomyces).*

14. **MONOSPORIUM** Bon. Handb. Alg. Myk. 95. 1851.

Sporophores irregularly or oppositely branched, the ultimate branches typically dichotomous or pseudo-verticillate, hyaline; conidia simple, hyaline or bright-colored.

1 species is reported from the United States.

15. **ACROSTALAGMUS** Corda. Ic. Fung. **2**: 15. 1838.

Sporophores verticillately branched, hyaline or bright-colored; conidia simple, hyaline, capitate, involved in mucus.

1 species is reported from the United States. Contains conidial stages of *Nectria.*

16. **STACHYLIDIUM** Lk. Obs. Myc. **1**: 13. 1809.

Sporophores verticillately branched, fuscous; conidia capitate, globose or elliptical.

2 species are described from this country.

17. **CHAETOPSIS** Grev. Scot. Crypt. Fl. 358.

Mesobotrys Sacc. Mich. **2**:27. 1880.

Sporophores simply verticillate in the middle, the upper portion sterile, simple or branched, fuscous; conidia solitary, hyaline, ovoid or cylindrical.

1 species is reported from the United States.

18. **GONYTRICHUM** Nees. Act. Acad. Leop. 9: 244. 1818.

Sporophores irregularly branched, fuscous; conidia solitary, simple, borne upon verticillate sterigmata (basidia) arising at the nodes of the sporophores.

1 species reported.

Tribe **Dematieae** (Fr.)

Dematiei Fr. Syst. Myc. **3**:335. 1832.
Haplographieae Sacc. Syl. Fung. **4**:303. 1886.

Vegetative hyphae creeping; sporophores erect or ascending, verticillately or irregularly branched, or simple, the branches being reduced to mere denticulations at the apex, hyaline or fuscous; conidia catenulate, simple, hyaline or fuscous, catenulae acrogenous, single on the ultimate branches or sterigmata (basidia).

19. **DEMATIUM** Pers. Tent. Disp. Meth. Fung. 41. 1797.

Sporophores ascending, irregularly branched, fuscous; conidia simple, fuscous, globose or ovoid, catenulae scattered.

3 species are reported from the United States.

20. **SCHIZOCEPHALUM** Preuss. Linn. **25**: 77. 1852.

Hormodendron Bon. Bot. Zeit. **1853**:286. 1853.
Haplographium B. & Br. Ann. Mag. Nat. Hist. III no. 281 1859 p. p.

Sporophores erect, more or less verticillately branched at the apex, fuscous; conidia fuscous, globose to oblong, catenulae approximate.

As here limited, contains 3 North American species:

Schizocephalum atro-brunneum (Cke.)
Penicillium atro-brunneum Cke. Grev. **6**: 139. 1878.
Haplographium atro-brunneum Sacc. Syl. Fung. **4**: 305. 1886.
Schizocephalum divaricatum (Ell. & Langl.)
Hormodendron divaricatum Ell. & Langl. Journ. Myc. **6**: 35. 1890.
Schizocephalum griseum (Ell. & Langl.)
Haplographium griseum Ell. & Langl. Journ. Myc. **4**: 124. 1888.

21. **SPICARIA** Harz. Hyphom. 50. 1871.

Sporophores erect, hyaline, branches perfectly verticillate; conidia hyaline, ovoid or oblong.

1 species is reported from this country.

22. **HAPLOGRAPHIUM** B. & Br. Ann. Mag. Nat. Hist. no. 818. 1859.

Sporophores erect, fuscous, the apex inflated, denticulate; conidia fuscous, simple, globose to oblong, catenulate, the catenulae arising from the terminal denticulations of the sporophore.

The species in which the sporophores are branched at the apex are referred to *Schizocephalum*. We retain here only those in which the branches are reduced to mere denticulations. But one species is reported from the United States, which may be included in the genus as here limited,—*H. apiculatum* Pk.

Tribe **Stachybotryteae.**

Vegetative hyphae present, creeping; sporophores erect, branched or simple, bearing verticillate sterigmata (basidia) at the apex, fuscous or hyaline; conidia single, solitary, acrogenous or acropleurogenous.

23. **STACHYBOTRYS** Corda. Ic. Fung. **1**:21. 1837.

Sporophores erect, elongate, branched, rarely simple, crowned at the apex with heterogeneous, verticillate sterigmata which are connate at the base, fuscous; conidia acrogenous, globose or ovoid, fuscous, simple, rarely 1-septate.

5 species are reported from this country. Several of the species are stages of *Chaetomium*.

24. **STERIGMATOBOTRYS** Oudem. Contr. Myc. Pays Bas. **11**:48.

Sporophores erect, typically simple, crowned at the apex with free, heterogeneous sterigmata, fuscous; conidia acropleurogenous, globose or ovoid, fuscous, simple.

1 species is reported from the United States:

Sterigmatobotrys elongata (Pk.)
Stachybotrys elongata Pk. Rep. N. Y. Mus. **43**:—(29). *Pl. 3. f. 10-13.* 1890.

25. **CYLINDROCLADIUM** Morg. Bot. Gaz. **17**:191. 1892.

Sporophores erect, di- or trichotomously branched, the tips crowned with 2—3 verticillate sterigmata, hyaline; conidia acrogenous elongate-cylindrical, 1-septate, hyaline.

1 species is described.

Tribe **Botryteae** (Fr.)

Botrytidei Fr. Summ. Veg. Scand. **2**: 490. 1849.

Sporophores erect, ascending, or decumbent, not rigid, generally much branched; conidia pleurogenous, acropleurogenous, or solitary acrogenous on short lateral branches.

26. **BOTRYTIS** Pers. Tent. Disp. Meth. Fung. 40. 1797.

Sporophores erect, irregularly much branched, tips of the branchlets acute or sub-acute; conidia simple, clustered, acro-pleurogenous or pleurogenous on the upper portions of the branchlets.

Saccardo includes *Polyactis* and *Phymatotrichum* in this genus. But, while the latter resemble *Botrytis* in bearing clusters of conidia at or near the tips of the branchlets, they appear more closely related to *Botryosporium* and the *Cephalosporieae.* The typical *Botrytis* forms for the most part belong to various *Sphaeriaceae.* Some are stages of *Hypoxylon*, one belongs to *Melanospora.* *Polyactis* for the most part contains conidial forms of *Sclerotinia.* Even with *Polyactis* and *Phymatotrichum* removed, the group is very heterogeneous and unsatisfactory. The species with pleurogenous conidia are not readily separable from *Haplaria* and *Sporotrichum.*

About 35 species are reported from the United States.

27. **HAPLARIA** Lk. Obs. Myc. **1**: 9. 1809.

Acladium Lk. Obs. Myc. **1**: 9. 1809.
Virgaria Nees. Syst. Pilz. **2**: 14. 1816.

Vegetative hyphae creeping; sporophores erect, branched or simple, light colored or fuscous; conidia pleurogenous, simple.

Acladium differs only in having unbranched sporophores. *Virgaria* is composed of forms which may well be referred to *Haplaria*—differing only in color and in the somewhat more rigid sporophore—and of a few dark colored species of *Botrytis.*

11 species are reported from the United States.

28. **SPOROTRICHUM** Lk. Obs. Myc. **1**: 9. 1809.

Trichosporium Fr. Summ. Veg. Scand. **2**: 492. 1849.

Vegetative hyphae and sporophores decumbent, sporophores irregularly much branched or simple; conidia pleurogenous or acro-pleurogenous upon the branchlets, sub-solitary, simple.

Differs from *Botrytis* in the decumbent sporophores and sub-solitary conidia. Saccardo separates the dark-colored forms under *Trichosporium.*

About 25 species are reported from the United States. Some of the species are stages of *Chaetomium.*

29. **CAMPSOTRICHUM** EHRB. Sylv. Myc. Berol. 11. 1818.

Vegetative hyphae and sporophores sub-decumbent, dark-colored, intricately branched, the branches divaricate, hamate, or flagelliform; conidia pleurogenous, borne in clusters near the tips of the branchlets, hyaline or dark-colored, simple.

3 species are reported from the United States.

30. **GLENOSPORA** B. & C. Grev. 4:161. 1876.

Parasitic; hyphae interwoven into a black crust; sporophores ascending, forked or with short branches; conidia acro-pleurogenous, or acrogenous on the tips of short lateral branches, simple.

2 species are reported from the United States.

31. **STREPTOTHRIX** CORDA. Prachtfl. 23. 1839.

Sporophores erect, dark-colored, virgate-branched, the branches and branchlets spirally flexuous; conidia pleurogenous, solitary acrogenous, or borne on short filiform processes at the ends of the branchlets, simple.

4 species are reported from this country.

32. **RHINOTRICHUM** CORDA. Ic. Fung. **1**:17. 1837.

Sporophores erect, light-colored, simple or sub-simple, the tips denticulate; conidia borne on the denticulations, simple.

21 species are reported from the United States.

33. **OLPITRICHUM** ATKINSON. Bot. Gaz. **19**:244. 1894.

Mycelium creeping; sporophores erect, simple or little branched, near the apex provided with flask-shaped, fusoid, or enlarged sterigmata, each bearing a single, simple, conidium.

Differs from *Rhinotrichum* in the inflated denticulations or sterigmata.

1 species only is described.

In *Physospora* the denticulations are borne on swellings of the sporophore. No species are reported from North America.

34. **ACREMONIUM** LK. Obs. Myc. **1**:13. 1809.

Acremoniella SACC. Fung. Ital. *f. 713.* 1881.

Hyphae creeping, simple or sparingly branched; conidia solitary on the ends of scattered, slender, simple, sub-erect branches, simple.

Saccardo separates the dark-colored forms under *Acremoniella.*

5 species are reported from this country.

35. **ZYGODESMUS** CORDA. Ic. Fung. **1**:11. 1837.

Hyphae creeping, irregularly branched, with numerous lateral swellings at the septa ("clamp-joints"); conidia muriculate, rarely smooth, simple, borne on denticulations, or solitary on short lateral branches.

Many of the described species are *Basidiomycetes* e. g. *Z. fuscus* CORDA is *Tomentella ferruginea* PERS. About 14 species are repoı ted from the United States, excluding those that certainly belong elsewhere.

36. **SEPEDONIUM** LK. Obs. Myc. **1**:16. 1809.

Light-colored, hyphae all decumbent, branching; spores borne singly or in clusters of 2–3 on the ends of branchlets, echinulate, simple.

The species which are parasitic on fungi are stages of *Hypomyces.* 4 species are reported from the United States.

37. **MYCOGONE** LK. Obs. Myc. **1**:16. 1809.

Like the preceding, but spores 1-septate, the upper cell the larger and usually echinulate.

2 species reported from the United States; stages of *Hypomyces*, except *M. anceps* SACC., which is the chlamydosporous state of *Hydrogera oedipus* and should be excluded.

38. **SYNTHETOSPORA** MORG. Bot. Gaz. **17**:192. 1892.

Hyphae all decumbent, branched, intricate; spores borne on the ends of short lateral branchlets, each spore consisting of a large opaque central cell with several smaller hyaline cells sunk part way into its surface.

1 species described; "a compound *Mycogone.*" (MORGAN).

Tribe **Periconieae** SACC. Syl. Fung. **4**:269. 1886.

Vegetative mycelium sparse or none; sporophores erect, rigid, dark-colored, simple or sub-simple; conidia pleurogenous, or borne along the tips of the sporophores on denticulations, simple.

39. **CHLORIDIUM** LK. Obs. Myc, **1**:11. 1809.

Sporophores sub-simple, fuscous; conidia oblong or globose, pleurogenous on the upper portion of the sporophores.

2 species are reported from the United States.

40. **PERICONIA** TODE. Fung. Mecklenb. 2:2. 1791.

Vegetative hyphae creeping, generally obsolete; sporophores simple, fuscous; conidia borne upon denticulations or short sterigmata at and near the apex in a dense head.

7 species are reported from the United States.

41. **CAMPTOUM** LK. Sp. Pl. 1:44. 1824.

Vegetative hyphae obsolete; sporophores simple, hyaline with fuscous bands at regular intervals, at and near the apex verrucolose-sporigerous; conidia fuscous, boat-shaped, curved or inequilateral.

1 species is reported from the United States.

42. **OEDEMIUM** LK. Sp. Pl. 1:42. 1824.

Sporophores erect, rigid, opaque, simple or sub-simple, at the apex or laterally here and there bearing rather large, subglobose swellings; conidia globose, pleurogenous upon the lateral or apical swellings.

2 species are reported from the United States.

Tribe **Polyactideae** (CORDA.)
Polyactidei CORDA. Prachtfl. 33. 1842.

Sporophores erect, light-colored or grayish, very long, much branched; branchlets obtuse or inflated near the apex, bearing simple, single conidia in dense capitula.

The conidia are sessile pleurogenous or borne on denticulations at or near the tips of the branchlets.

43. **POLYACTIS** LK. Obs. Myc. 1:14. 1809.

Sporophores grayish or fuscescent, rather rigid, the branchlets thickened towards the tip, but not lobed or much swollen, the thickened portion denticulate; conidia racemose upon the denticulations.

About 10 species are reported from the United States.

44. **PHYMATOTRICHUM** BON. Handb. Alg. Myk. 116. 1851.

Sporophores hyaline or light-colored, the tips of the branches inflated and somewhat lobed or crenate or digitate without inflation; conidia borne in heads upon the denticulate or muriculate lobes and inflations.

4 species are reported from the United States.

45. **BOTRYOSPORIUM** CORDA. Sturm. Deutsch. Crypt. Fl. III, **11**: 9. 1831, not SCHW. 1834.

Sporophores hyaline, simple or furcate, with alternate or opposite lateral branchlets, branchlets simple, at the apex bearing 3–5 spicules upon which the conidia are borne in heads; conidia hyaline, globose or ovoid.

2 species are reported from the United States. *Botryosporium prorumpens* SCHW. is a *Speira.* Saccardo gives it under *Botryosporium* and also as *Speira erumpens* (SCHW.), evidently an error for *prorumpens.*

Tribe **Cephalosporieae** SACC. Syl. Fung. **4**: 47. 1886.

Vegetative hyphae either creeping or rhizoid-like; sporophores erect or ascending, usually simple, generally somewhat inflated above, hyaline; conidia simple, single, i. e. not catenulate, capitate-clustered, typically on the apex of the sporophore, hyaline or light-colored.

46. **HAPLOTRICHUM** LK. Sp. Pl. **1**: 52. 1824.

Hyalopus CORDA. Anleit. 58. 1842.
Cephalosporium CORDA. Anleit. 61. 1842.

Sporophore simple, erect, slightly or not at all inflated at the apex; conidia capitate-clustered, sessile, globose to elliptical.

The three genera, usually distinguished, do not seem sufficiently well marked to be maintained. *Haplotrichum* has 6 species reported from the United States, including the following, brought over with *Cephalosporium* and *Hyalopus:*

HAPLOTRICHUM ACREMONIUM (CORDA).
Cephalosporium acremonium CORDA. Ic. Fung. **3**: 11. *Pl. 2. f. 29.* 1839.

HAPLOTRICHUM GRISEUM (B. & C.)
Hyalopus griseus B. & C. Grev. **3**: 64. 1874.

HAPLOTRICHUM MUCORINUM (B. & C.)
Hyalopus mucorinus B. & C. Grev. **3**: 64. 1874.

HAPLOTRICHUM PARASITANS (B. & C.)
Hyalopus parasitans B. & C. Grev. **3**: 64. 1874.

47. **CYLINDROCEPHALUM** BON. Handb. Alg. Myk. 103. 1851

Vegetative hyphae obsolete; sporophores simple, erect, hyaline; conidia capitate, sessile, cylindrical, hyaline.

1 species is reported from the United States.

48. **OEDOCEPHALUM** PREUSS. Linn. **24**: 31. 1851.

Vegetative hyphae creeping; sporophores erect, simple, hyaline, vesiculose-inflated at the apex, vesiculae scarcely areolate; conidia capitate, sub-stipitate, globose to oblong, hyaline.

4 species are reported from the United States.

49. **RHOPALOMYCES** CORDA. Prachtfl. 3. 1839

Vegetative hyphae rhizoid-like; sporophores erect, generally simple, vesiculose-inflated, vesiculae areolate; conidia stipitate, ellipsoid to oblong, hyaline.

2 species are reported from the United States.

50. **SIGMOIDEOMYCES** THAXT. Bot. Gaz. **16**: 22. 1891.

Sporophores erect, much-branched, bearing sub-dichotomous sigmoid vesiculae on short lateral branches; conidia stipitate, hyaline.

1 species described.

[*To be Continued.*]

XL. ON THE STEM ANATOMY OF CERTAIN ONAGRACEAE.

FRANCIS RAMALEY.

Introduction.—During the past year a comparative study has been made of the minute anatomy of the stem in a considerable number of genera of Onagraceae. The plants investigated are all of the tribe Onagreae, a group, the members of which show strong natural affinities.

The chief purpose of the paper is to give an accurate account of the stem anatomy in the plants examined, together with a brief historical summary of the literature bearing upon the points of greatest interest. For the sake of simplicity this historical account has been greatly compressed and divided into separate sections. References to text books have not been given.

The nomenclature used is that of the Check List.[1] This has been followed merely for convenience and because it has seemed best, in a purely morphological paper, to avoid nomenclatural difficulties. Only plants enumerated in the check list have been examined. These are all indigenous, and, as a rule, restricted to North America, although Onagra biennis was, according to Raimann,[2] introduced into Europe at the beginning of the seventeenth century and is now a common roadside weed.

Taxonomic value of anatomical characters.—The importance of histological characters in drawing specific descriptions has been discussed at some length by Vesque.[3,4] In his monograph on the Guttiferae[5] he makes continual use of microscopic differences for purposes of classification. Weiss,[6] in an article

1. Mem. Torr. Bot. Club. **5**: 233-236. 1894.
2. Onagraceae in Engler and Prantl, Nat. Pfl. Fam. **3**: Abt. 7. 199. 1893.
3. **Vesque, J.** De la concomitance des charactères anatomiques et organographiques des plantes.—Comptes rendus. **96**: 1866-1868. 1883.
4. **Vesque, J.** L'anatomie des tissus appliquée a la classification des plantes.—Mem. II, Nouv. Arch. du Mus. d'hist. natur. II. **5**: 291-387. 1883.
5. **Vesque, J.** Guttiferae. — DeCandolle. Monographiae Phanerogamarum **8**. 1893.
6. **Weiss, J. E.** Beitraege zur Kenntniss der Kork-bildung. Denkschriften der Kgl. Bayerischen Botan. Ges. zu Regensburg. **6**: 1890.

on the growth of cork, shows how cork is of some taxonomic value, for, in its formation, it is noted as always having its origin in the same cell zone, in any given species. Solereder,[7] in 1885, published an extended work on the systematic value of the structure of wood. In Peterson's work,[8] on bicollateral vascular bundles, some little attention is given to the importance of this character for purposes of systematic description.

The pharmacologists have for a long time distinguished various cellular vegetable drugs by the microscopic appearance of their cross sections. As a rule, however, the descriptions are not sufficiently accurate or minute to serve for the discrimination of closely allied species. In the case of Cinchona barks elaborate classifications have been formulated, based largely upon the size and arrangement of the bast fibres and of laticiferous vessels. One of the best of these is given by Maish.[9] The present writer has not found this classification of any very great value.

Gibson,[10] in studying the stem anatomy of Selaginella, found marked histological differences in the species; but his grouping of the species, on these characters—and to this he calls special attention—does not agree with the usual grouping of the systematists. He says (p. 201), "How far comparative anatomy may serve as a basis for a revision of the established classification of the Selaginellaceae, and how far it supports or otherwise, external morphology can only be determined after extended observation on all the members, and not the stem alone." This last statement might be made with equal propriety, concerning those Onagraceae discussed in this paper.

Bicollateral vascular bundles.—As is well known, the existence of bicollateral bundles was first announced by Hartig,[11] who discovered them in Cucurbita. Von Mohl,[12] and numerous other writers have contributed to our knowledge of the subject. The following review of researches on bicollateral vascular bundles, especially in Onragraceae, will serve to point out the progress of investigation in this direction.

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7. **Solereder.** Ueber den systematischen Werth der Holzstructur bei den Dicotyledonen. 1885.
8. **Peterson.** Ueber das Auftreten bicollateraler Gefässbündel u. s. w. Engler's Botanische Jahrbücher **3**: 359. 1882.
9. **Maish, J. M.** Organic Materia Medica, Ed. VI. 1895.
10. **Gibson.** Contributions towards a Knowledge of the Anatomy of the Genus Selaginella, Spr.—Annals of Botany **8**: 133. 1894.
11. **Hartig.** Ueber die Querscheidewände zwischen den einzelnen Gliedern der Siebröhren in Cucurbita pepo.—Bot. Ztg. **12**: 51. 1854.
12. **Von Mohl.** Einige Andeutungen über den Bau des Bastes.—Bot. Ztg. 880. 1855.

Russow,[13] in 1875, published an account of what was at that time known concerning the vascular tissue of plants. In this work the author discusses the evolution of the vascular bundle, upward from the lowest type. In a classification of various plants according to their bundles, he places the Onagraceae among those in which there are two protophloem and one protoxylem group in each vascular bundle.

Bicollateral vascular bundles in the root of Onagra biennis were discovered by Weiss[14] in 1880. Incidentally, this author states that in the medullary phloem of the stem there are often found thick walled bast cells and that these are not found in the intra-xylar phloem of the roots.

Peterson,[15] in discussing the bicollateral character of the bundles in Onagraceae speaks of Oenothera odorata, and states that the outer bast is but slightly developed while there is a good development of inner bast which early forms an almost continuous ring of tissue. Upon the border near the primary bark is a nearly unbroken ring of bast fibres. Oe. gauroides and Oe. longiflora are of like structure except that there are also bast fibres in the inner phloem. According to Weiss the same is the case with Oe. biennis (Onagra biennis). Most of the Oenothera species have bundles of bast fibres in the outer portion of the bast, and when cork formation takes place, which occurs very often, the cork is developed internally to the fibres.

Scott,[16] in an article in the *Annals of Botany*, devotes some space to the consideration of *internal phloem*. This, he says, is characteristic of a large number of dicotyledonous orders, usually, though not always very highly organized ones; Myrtaceae, Onagraceae and all allied orders, Campanulaceae, Compositae, Cucurbitaceae, etc. This internal phloem may occur as distinct phloem strands or as a part of complete medullary bundles. Internal phloem very often has cambial increase like the normal tissues. The article is followed by a good bibliography.

Mlle. Fremont[17] found sieve tubes in the pith of the root of Oenothera fraseri and Oe. riparia. She also found them in the secondary wood of the roots of Oe. parviflora, cruciata, macro-

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13 **Russow, E.** Betrachtungen über das Leitbündel und Grundgewebe aus vergleichend morphologischen und phylogenetischen Standpunkt. Dorpat. 1875.

14 **Weiss, J. E.** Anatomie und Physiologie fleishig verdickten Wurzeln. Flora. **63**: 97. 1880.

15 **Peterson, O. G.** loc. cit.

16 **Scott.** On some recent Progress in our Knowledge of the Anatomy of Plants. Annals of Botany. **4**: 147. 1889.

17 **Fremont.** Sur les tubes criblés extralibériens, dans la racine des Oenothéracées. Morot. Journ. de Bot. **5**: 194. 1891.

carpa, sellowi and fraseri. These, she considers to be developed by a differentiation of the wood parenchyma. The first part of her paper is devoted to an historical review of investigations on the sieve tubes in roots occurring outside the usual bast area.

In an article on internal phloem in roots and stems, Messrs. Scott and Brebner,[18] enumerate the various plant families in which bicollaterality of the vascular tissue has been noted. Among them is the family Onagraceae. The authors state that, in general, this character is constant in each family named with the occasional exception of a divergent tribe. A review of Lamounette's work[19] is given in a postscript. This investigator found, in the Onagraceae, internal phloem to be entirely absent from the hypocotyl, cotyledons, and even the earlier formed leaves. So far as the hypocotyl is concerned, Messrs. Scott and Brebner say it can only be true of very young plants. We know from Weiss's observations that the internal phloem is continued into the root where it forms the innermost inter-xylar phloem strands.

Intra-xylar phloem.—The presence of strands of thin walled cells in the secondary wood of certain stems and roots seems to have been first described by Fritz Müller[20] in 1866. This author made no extended observations; he simply announced his discovery and made a diagrammatic figure of a cross section of the stem of Strychnos, a plant in which the islands are numerous and well marked. These strands of thin walled cells, from their appearance in a transverse section of the member came to be spoken of as "islands." In some cases, at least, they contain sieve tubes and so the name "intra-xylar phloem island," or briefly "phloem island" was applied and is now in general use.

In DeBary's *Comparative Anatomy*,[21] the intra-xylar phloem in Strychnos is discussed, and it is definitely stated that the tissue of the phloem islands is developed internally to the cambium. A diagrammatic figure to illustrate this point is given.

One of the earliest investigations on intra-xylar phloem, was made by Weiss.[22] He found that the parenchymatous xylem of

18 **Scott and Brebner.** On internal Phloem in the Root and Stem of Dicotyledons. Annals of Botany **5**: 259. 1891.

19 **Lamounette.** Recherches sur l'origin morphol. du liber interne. Ann. Sc. Nat. VII. **11**: 193-278.

20 **Mueller.** Uber das Holz einiger um Desterro wachsenden Kletterpflanzen.—Bot. Ztg. **24**:65. 1866.

21 **DeBary.** Comparative Anatomy of the Vegetative Organs of the Phanerogam and Ferns. (English Translation.)

22 **Weiss.** loc. cit.

fleshy roots of plants with bicollateral stem structure contains strands of phloem produced internally by the cambium. This was found in various Onagraceae, Gentianaceae and Solanaceae. In Oenothera longiflora Jacq., he found centrifugally formed intra-xylar phloem in the root. Of this tissue the larger part was seen to be parenchyma containing small groups of sieve tubes.

Solereder[23] made extended observations of phloem islands in a large number of plants belonging to various families; the Onagraceae were, however, not investigated. The researches of Hérail[24] and Kolderup-Rosenvinge[25] have also added to our knowledge of these structures in certain genera.

The investigations of Messrs. Scott and Brebner,[26] at first on Strychnos, and afterward on numerous other plants[27] are of interest. The writers criticize the work of DeBary, and find his statement that the intra-xylar phloem in Strychnos is developed centrifugally to be incorrect. They find that there are masses of crushed tissue at the outside of the islands, that the islands grow from an internal cambium and that this growth gradually crushes the older effete cells, farther out. In some cases medullary rays may be seen extending through the phloem islands. Thirteen plant families are enumerated in which phloem islands occur.

The subject has been investigated by Scott,[28, 29] Fremont,[30] Van Tieghem,[31] Leonhard[32] and others. A good drawing of an island is given in *Taf. 11, fig. 3,* in connection with Leonhard's work, Chodat[33, 34] has made a study of the different modes of

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23 **Solereder.** loc. cit.

24 **Herail.** Recherches sur l'anatomie comparée de la tige des Dicotylédones. Ann. des Sc. Nat. VII. **2**: 1885.

25 **Kolderup-Rosenvinge.** Anatomisk Ondersögelse af Vegetationsorganerne hos Salvadora.—Oversigt K. Dansk. Selskabs. 1880-1881.

26 **Scott and Brebner.** On the Anatomy and Histogeny of Strychnos.—Annals of Botany **3**: 275. 1889.

27 **Scott and Brebner.** On internal Phloem in the Root and Stem of Dicotyledons.—Annals of Botany **5**: 259. 1891.

28 **Scott.** On some recent progress in our knowledge of the anatomy of plants.—Annals of Botany **4**: 147. 1889.

29 **Scott.** On some Peculiarities in the Anatomy of Ipomoea versicolor Meissn.—Annals of Botany **5**: 173. 1891.

30 **Fremont.** loc. cit.

31 **Van Tieghem.** Sur les tubes criblés extra-libériens, etc. Morot. Journ. de botanique **5**: 117. 1891.

32 **Leonard.** Beiträge zur Anatomie der Apocynaceen. Bot. Centtralbl. **45**. 1891.

33 **Chodat, R.** Contribution a l'ètude des anomalies du bois. Atti del congresso botanico internazionale di Genova. 144-156. 1893.

34 **Chodat, R.** Nouvelles recherches sur l'origine des tubes criblés dans le bois. Archives des sciences physiques et naturelles, 1892. This and the foregoing article are reviewed by Schimper in Bot. Centralbl. **55**: 277. 1893.

origin of the islands. In the majority of cases, according to this investigator, the intra-xylar islands have their origin in the cambium, and are developed exclusively in a centrifugal manner. Oenothera furnishes an example of this method of formation. He states that there are but three genera known at the present time, in which the phloem islands are developed centripetally. These are Strychnos, Memecylon, Guiera.

The latest contribution to the subject is by Perrott,[35] who has made a careful study of the development of the phloem islands in Strychnos. He confirms, in general, the observations of Scott and Brebner, though disagreeing in some points. No reference is made to any species of Onagraceae.

Methods.—For most of the work carefully determined herbarium material was employed. Of the Minnesota species sections from fresh material were also examined. Whenever possible a number of specimens of each species from different localities were used. Portions of the stem were taken at different heights. Some of these pieces were placed in 2 per cent. potassium hydrate solution for twelve hours and, after being thoroughly washed in water, were put through the usual process preparatory to section cutting. Other pieces were put at once into 10 per cent. alcohol and from that carried up through the higher grades of alcohol in the ordinary manner.

Various stains were used. The most satisfactory ones tried were a watery solution of fuchsin and methyl blue, and a solution of fuchsin and iodine green in 40 per cent. alcohol. Both these combination stains give good differentiation. The best results were obtained by employing the stains in very dilute form, allowing them to act from twelve to twenty-four hours. By using an eosin-haematoxlin stain some excellent preparations were also made. Permanent mounts in Canada balsam were preserved of all the sections examined.

In order to dissociate the separate elements for careful study pieces of stem previously soaked in water were treated with Schulze's macerating mixture. When diluted with an equal quantity of water this mixture was found to be sufficiently strong. Only in macerated material could the length of stereids and wood fibres be at all accurately determined.

For examination of the epidermis it was merely necessary to place thin portions of the cortex in water for from one to two hours, when the desired tissue could be peeled off with little

35 **Perrot.** Sur les ilots libériens intraligneux des Strychnos.—Morot, Journ. de Bot. 9: 90. 1896.

difficulty. No permanent mounts were made. To insure accuracy, most of the drawings were made with the aid of a camera lucida.

List of plants investigated.—The following plants were examined: Anogra pallida (LINDL.) BRITTON, Galpinsia hartwegii (BENTH.) BRITTON, Kneiffia fruticosa (LINN.) RAIMANN, Kneiffia glauca (MICHX.) SPACH, Kneiffia linearis (MICHX.) SPACH, Kneiffia linifolia (NUTT.) SPACH, Kneiffia pumila (LINN.) SPACH, Megapterium missouriensis (SIMS) SPACH, Meriolix serrulata (NUTT.) WALP., Oenothera humifusa NUTT., Oenothera sinuata LINN., Onagra biennis (LINN.) SCOP.

Epidermis.—The cells of the epidermis are similar in all the species examined. In cross section they are square or more often oblong, the walls are rather thick, the outer wall is bulged. In surface view the cells appear more or less oblong, narrowed at the ends, or they may be described as elongated hexagonal in outline.

The dimensions of the epidermal cells are by no means constant even throughout the same plant. Perhaps an average cell is 100mik. in length, with its tangential and radial diameters 25mik. and 20mik. respectively. As a rule no definite layer of cuticle is to be recognized, nor is there any considerable thickening of the outer walls of the cells. In some cases, however, the outer wall is somewhat noticeably thickened and occasionally shows, on a properly stained section, a distinctively stratified structure (Kneiffia glauca). The chief differences noticeable in the epidermis are in the length of the cells, the number, shape and size of trichome structures and the number of stomata. This last character is, however, of no considerable taxonomic importance since the number of stomata varies with the particular plant and in any given plant with the part examined.

The epidermis and the cortical layer are absent in older parts of the stem, being pushed out by the developing cork. In certain species the cork begins growth very early; notable for this peculiarity are Anogra pallida, Kneiffia fruticosa and linifolia and Galpinsia hartwegii. The first named is particularly remarkable in this respect, and it is only in the very youngest parts that the epidermis remains.

The epidermal hairs are never branched. As a rule they are straight or slightly curved, pointed at the end and commonly unicellular. The hairs vary considerably in length, averaging,

perhaps, 100 or 200mik.; sometimes they are 1 to 2mm. In Oenothera humifusa many of the hairs are placed upon large multicellular emergences. This occurs occasionally also in some of the other species. Besides the usual long, straight or slightly curved hairs there are often present short clavate ones, not much longer than the epidermal cells, e. g., Galpinsia hartwegii and Oenothera sinuata.

Sub-epidermis.—This consists usually of a narrow zone of collenchyma enclosing a greater or less amount of parenchyma. In some cases the cells of the first one or two rows below the epidermis might, perhaps, be best described as sclerenchyma. They resemble very much, when seen in cross section, the epidermal cells. Occasionally there is but one such row, so that the epidermis appears two-layered. In no case is the collenchyma greatly thickened at the angles. The collenchyma usually, though not always, shades gradually into parenchyma. In Oenothera humifusa, and, at times, in other species, there is but a single layer of thick-walled cells within the epidermis. This species is also remarkable for its numerous large emergences, at the bases of which are often situated crystal sacs. Emergences commonly, however of smaller size and fewer in number, are found in all the species examined. These, as a rule, seem not to offer communication with the outside world, but are simply irregular thickenings of the cortical layer.

The cells in both the collenchymatous and parenchymatous portions are somewhat flattened in the plane parallel to the epidermis. When seen in cross section they are often twice as long as broad. There is considerable difference in the thickness of the parenchymatous zone, depending upon the species and the particular plant examined. Sometimes this zone is but a very few cells broad, e. g., in Kneiffia fruticosa, where the whole sub-epidermal area is, for the most part, poorly developed.

Cells containing raphides of calcium oxalate are commonly abundant in the parenchymatous tissue. This is especially the case in those stems in which the cortical parenchyma is well developed. It is to be noted that the crystal sacs are not distributed evenly along all parts of the stem, but are very irregular as to their occurence. A cross section of the stem taken at a certain height may contain but a few crystallogenous cells, while one taken a millimeter above or below it may show them in great abundance. These cells are commonly of considerable size, nearly circular, in cross section about 30 to 40mik. in diam-

eter. In longitudinal section they are seen to be greatly elongated, often from 100 to 250mik. in length. In Kneiffia glauca and Kneiffia pumila no crystal sacs were observed.

The differences of different stems shown in the sub-epidermis are in the relative amounts of sclerenchyma and collenchyma, the thickness of the parenchymatous zone and the presence or absence of crystal bearing cells. In some cases the same species will afford as marked differences, in different plants, as are found in the most widely separated species which were examined.

Endodermis.—This is, at least in herbarium material of any considerable age, very indistinctly differentiated from the adjacent cells. It cannot ordinarily be distinguished except from its position as just outside the groups of pericyclic stereome. The cells, seen in cross section, appear elliptical or flattened in outline.

Pericycle.—This is in all cases heterogeneous and a number of cells in thickness. The cells are usually somewhat flattened, ellipsoidal in shape, the longitudinal diameter commonly the longest, the radial the shortest. Toward the outer boundary of the pericycle are groups of thick-walled fibrous cells. These cells are often 200 to 400mik. long; they have a narrow lumen. In cross section they appear five or six-sided. The middle lamella is usually quite distinct. The cell walls are ordinarily of unmodified cellulose. In some of the sections they present a somewhat marked lignin reaction. Apparently this lignification is not confined to or characteristic of any one or greater number of species. The stereome cells occur, in most cases, in patches of considerable size, three or four rows broad in a radial direction, the patches separated from each other by parenchyma (e. g., Onagra biennis, Anogra pallida, Oenothera rhombipetala). Sometimes this stereome area is very narrow, but a single cell broad, and forms a continuous or nearly continuous closed ring.

The cork is of pericyclic origin, essentially similar in all the species examined. It is made up of flattened rectangular prismatic cells of two sizes, arranged in alternating layers. The large cells have a radial diameter about four times as great as have the small ones. The latter commonly carry a brownish pigment. In Anogra pallida this pigment is, for the most part absent; this is also the case occasionally in other species. In the species named the cork in older parts shows a tendency to

split and become "shreddy," as it is described in the manuals. It is smooth and white in color.

All the cell walls are extremely thin, and it is only in the outer layers of cells, *i. e.* those at or near the surface that they are to any extent suberized. In this respect there can often be noticed a gradual transition from phellogen to mature cork. The large cells are usually somewhat bulged at the expense of the smaller ones. These latter may be so greatly compressed that their presence can only with difficulty be demonstrated. The radial walls of the large, as well as the small cells, when viewed in transverse section are mostly curved or wavy, seldom straight.

In the younger portions of the stem where the cortical tissues are still present the phellogen can be recognized as a few layers of thin walled cells having the shape of mature cork elements.

In most of the species the early development of the cork pushes out the overlaying tissues causing them to peel off. This is not always the case. In Megapterium missouriensis none of the sections examined showed any great development of cork; the cortex was in all cases present. Only three or four layers of immature cork cells could be seen; the inner ones were compressed and not of full size. A peculiarity in the cork of Meriolix serrulata deserves mention. In some of the sections examined numerous sclerotic cells are present, or rather some of the cork cells have very much thickened walls showing lamellation. This characteristic is, in many preparations, quite noticeable.

The average size of the large cells in cross section is perhaps 16mik. x 22mik. This oblong character is occasionally not strictly adhered to; in Kneiffia glauca the cells are in outline nearly square. In Galpinsia hartwegii, they are often of quite irregular shape. Whatever differences may be noted in the size of cork cells are not to be regarded as of any taxonomic importance, since considerable variation in this respect often occurs even in different parts of the same plant.

In nearly all cases crystallogenous cells are present in the pericycle; these are usually considerably larger than the ordinary parenchymatous elements; their longitudinal diameter is not infrequently 100 to 200mik. or even 280mik., e. g., Megapterium missouriensis.

A rather remarkable feature to be noted in Anogra pallida is the presence of crystal sacs, horizontally placed; *i. e.* with the

raphides lying parallel with the radial diameter of the cells. These are, however, far less numerous than the usual variety of crystal sacs.

Anatomically no sharp line can be drawn between pericycle and phloem; they shade imperceptibly into one another.

Phloem.—In cross section the phloem is not definitely marked off from the pericycle. Its cells, however, are usually somewhat smaller, and when crystal sacs are present they too are smaller than are those in the pericycle. In Kneiffia linearis and Kneiffia pumila no crystal sacs were observed.

The cells of the normal phloem are mostly parenchymatous. In cross section they are circular or elliptical. The long diameter of the cells of the phloem parenchyma is seldom over 25mik., as a rule not over 20mik. The cell walls are quite thin, and any investigation of the tissue in herbarium material is altogether unsatisfactory. Sieve tubes could not be demonstrated with certainty except in fresh material. In cross section they appear scattered in small groups through the parenchyma. There are no bast fibres.

Some of the species which grow to a considerable size have the phloem area fairly well developed, however, in most cases, it is but a few cells broad, usually six to twelve, occasionally even narrower. It may be forty cells or even more in breadth, (Onagra biennis, Megapterium missouriensis.) The cells of the phloem, though sometimes, for a part of the way irregularly placed are more often arranged in radiating rows. The medullary rays can often be distinctly traced as single rows of cells radially elongated.

The lack of phloem tissue in the usual position is perhaps compensated for by the presence of phloem elements in the pith, and in some species in small patches in the xylem.

Medullary phloem.—Apparently the vascular bundles of all the species may be described as bicollateral, whether or not this bicollaterality exists from the first or is the result of a secondary growth of tissue within the medulla can, of course, only be determined by an examination of very young material, showing the developmental stages. In Onagra biennis, the medullary phloem is developed in the hypocotyl of quite young seedlings.

The cells of the medullary phloem usually form distinct groups arranged with greater or less regularity in a circle toward the outside of the pith. Usually the cells are quite small, and are

easily distinguished from the fundamental tissue. There may or may not be parenchymatous cells between these phloem groups and the primary wood. The thick walled bast cells found by Weiss in the medullary phloem of Onagra biennis were not seen.

Intra-xylar phloem.—The intra-xylar phloem islands, as their name indicates, appear in transverse section, as isolated groups of phloem tissue. The cells of which they are composed have thin cellulose walls which are usually somewhat crushed and distorted. Some sections show these islands partly formed with the wood beginning to close in around them. The symmetry of the wood cells for some little distance just outside of one of these islands is in nearly every instance somewhat disturbed. In cross sections of fresh material the sieve tubes are distinctly seen.

It is a matter in which there is room for doubt as to whether or not all these islands contain, in reality, phloem tissue. In the few longitudinal sections obtained, which showed these groups at all well, the cells did not present the characteristics of vascular tissue. They are irregularly cylindrical or roughly bi-conical, not greatly elongated. As a rule the longitudinal diameter is not more than two or three times as great as the others.

These islands are not present in very young parts of the stem, nor do they occur in stems which attain only a slight thickness. They usually appear in cross sections as patches having a width of from three to eight cells in a radial direction and extending, in the direction parallel to the circumference of the section, from a distance of half a dozen cells to an eighth or a sixth of a circle. Commonly they are so arranged that they form more or less interrupted circles within the woody zone. In sections of thick portions of the stem, these circles are usually placed at about equal distances apart, and are readily distinguished if the preparations be stained with some appropriate mixture as fuchsin and methyl blue or iodine green.

Phloem islands were found in the following plants: Anogra pallida, Megapterium missouriensis, Oenothera rhombipetala, Oe. sinuata and Onagra biennis. In the first named species they are apparently not always present even in stems of some thickness. In Megapterium missouriensis small patches of phloem are to be seen in sections of stems which are 3mm. or more in thickness. Much larger patches are found in Oenothera rhombipetala. The islands in this species sometimes ex-

tend five to six cells in a radial direction and twenty or more in the direction parallel to the surface of the stem. In old portions of the stem of Oenothera sinuata the islands present a peculiarity in their arrangement. They are not disposed in interrupted circles as they are in the various other species, but appear to be scattered at random. In Onagra biennis the intra-xylar phloem islands are well developed in old parts. Some of these islands show in cross section but four or five cells, and many but seven or eight; still others consist of very considerable masses of tissue. The cells of this intra-xylar phloem in cross section are commonly small, not differing greatly in size from the smaller wood fibres. The islands first make their appearance about 0.5mm. from the pith. There is, however, considerable variation in this respect.

Cambium.—The cells of this tissue can, as a rule, only with difficulty, be recognized. They present no peculiarities in form and structure. In cross section the cambium, when discernible at all, appears as a narrow zone of thin-walled compressed or flattened cells, the long diameter generally between 10 and 15mik. In some cases the transition from wood to cambium and from cambium to phloem is quite abrupt; more usually a gradual transition occurs, at least between phloem and cambium. The different species present no characteristic peculiarities as to the development of cambial tissue. This seems rather to be dependent upon external conditions favorable or unfavorable to rapid growth.

Xylem.—The primary wood is composed of spiral vessels, fibres and parenchyma, usually in groups projecting into the pith. As a rule, the elements are not greatly lignified, though complete lignification sometimes occurs. The vessels are, in cross section, circular or elliptical in outline, not irregularly polygonal, as are often the pitted vessels of the secondary wood. The spiral thickening is sometimes in a single band; again it may be in two bands running in opposite directions; and in still other cases in two, three or four bands winding in the same direction. The average diameter of the spiral vessels varies from about 12mik. in Kneiffia fruticosa to nearly 25mik. in Onagra biennis.

The secondary wood is divided by the medullary rays into very many narrow wedges; these wedges, even at their widest portions, are seldom half a dozen cells broad. The wood usually shows considerable regularity in the arrangement of its

elements, the cells being placed in rather definite radiating rows. In those species where intra-xylar phloem islands occur this regularity is, however, broken in the parts just exterior to the islands. At these points the cells may be quite irregularly placed.

The vessels of the secondary xylem are usually pitted, though occasionally reticulated. They are often in groups of three, four or five, extended in a radial direction. In cross section the vessels appear irregularly polygonal or elliptical; the long axis, sometimes placed in a direction parallel to the circumference of the section, at other times at right angles to it. In a few cases it is somewhat oblique. The partially absorbed transverse septa are readily seen in longitudinal section. The individual elements are seen to be, as a rule, about three times as long as thick. The largest vessels noted in the secondary wood were 100mik. in diameter (Onagra biennis, Oenothera sinuata). Of the last named species a section 2mm. in diameter showed no vessels over 37mik., while one 4mm. in diameter from another plant has vessels of the size above stated. As a rule, species with slender stems have smaller vessels than those with robust stems. There is considerable variety in the number of vessels seen in different cross sections. Apparently the proportion of vessels to wood fibres is by no means constant.

The wood fibres are elongated fusiform elements, sharp-pointed at the ends. No branched fibres were observed. The walls are often of considerable thickness. In size the fibres average, perhaps, 200mik. in length and 10 or 15mik. in thickness at their widest part. In transverse section they appear more or less hexagonal in outline, fitting into each other without intercellular spaces. Occasionally some of the fibres are more or less triangular in cross section (Oenothera humifusa), or small, somewhat diamond-shaped cells may be found between those of hexagonal form (Oenothera rhombipetala). The fibres seen in cross section are commonly elongated in a tangential direction, but in some sections they are found to be at times radially elongated (Galpinsia hartwegii). The middle lamella is, in nearly all cases, distinctly discernible. It shows thickenings at the angles.

Medullary rays.—The medullary rays extending from the pith to the phloem are very numerous. There are also many secondary rays which take their origin at some distance from the pith. Some of the rays are traceable the whole distance through the phloem to the pericycle. More often, however,

the rays cannot be at all easily distinguished in the phloem. The separate elements of the rays are usually rectangular in outline. In cross section they appear elongated in a radial direction. In radial longitudinal section the cells are seen to be vertically elongated.

All these cells, so far as observed, have pitted walls. Some show marked reticulations and irregular thickenings. An inconsiderable amount of lignification is in some cases to be observed. Starch is occasionally present in the cell cavities. The starch grains show no peculiarities in form. They are circular in outline; no striations were observed.

In size the medullary ray cells show some variation. In Oenothera humifusa, Kneiffia linearis and Kneiffia linifolia the average diameters in cross section are generally 7 to 12mik. In some of the larger species the cells have diameters of 10 and 20mik. In respect to size, however, there is to be noted the fact that individual variations in plants of the same species may often be very great.

Pith.—The pith is composed of parenchymatous elements. That portion which is adjacent to the vascular bundles is commonly much smaller celled than the central part. Its cells are often somewhat flattened and crushed by the growth of the medullary phloem, which appears to be present to a greater or less extent in all the species examined.

The cells of the central portion of the pith are very large, frequently attaining a diameter of from 50 to 100mik. Starch may be present throughout. There are sometimes large intercellular spaces. Commonly the cells present no peculiarities in structure. In some species occasional thick-walled cells are found which take a lignin stain. These cells occur singly or in small groups. They are especially abundant in Kneiffia glauca, Oenothera humifusa and Kneiffia linifolia. In each case the cell wall shows, in stained sections, distinct lines of stratification. Crystal sacs are in many cases abundant. Seen in cross section they are nearly always circular or elliptical in outline and may be smaller than the ordinary parenchymatous cells, though, as a rule, they are larger. They are closely packed with raphides of calcium oxalate. These crystals are in no way different from those of the phloem and cortex. Crystal sacs may occur in the central portion of the pith; more often, however, they are placed not far from the medullary phloem.

Conclusions.

There seem to be no marked anatomical characters of the stem which can be set down as belonging to one species and to no other. Plants of the same species growing under different conditions may present as great differences as are to be noted between species of comparatively remote genera. Slight differences in the thickness of the various zones of tissue are evident, as are also variations in the size of the constituent elements in some of the tissues. The following generalizations may be drawn.

1. There is a striking similarity in stem structure througout all the seven genera examined. The stem anatomy will not serve to distinguish one genus from another.
2. The cortex is absent from old stems, being replaced by cork of characteristic structure.
3. The normal phloem is in all cases poorly developed.
4. Bicollateral vascular bundles occur in all the species examined.
5. Intra xylar phloem islands are found in the stems of all the robust species.
6. Raphides of calcium oxalate are present in all cases. These generally occur in both cortex and pith, often in the pericycle and phloem.

EXPLANATION OF PLATES.

Plate XXXVI.

Anogra pallida.—1. A crystallogenous cell in the pericycle seen in longitudinal section. 2. Transverse section of a portion of an old stem; showing bast, inner pericycle and cork; two crystallogenous cells in the pericycle. 3. Longitudinal section showing cork and adjacent cells. Raphides of calcium oxalate are shown in one of these. 4. Surface view of cork.

Galpinsia hartwegii.—5. Cork in longitudinal section, showing sclerotic cells. 6. Cork and subjacent tissues. 7. Cork in transverse section. 8. Portion of a tangential longitudinal section through the secondary wood; medullary rays cut across. 9. Portion of the epidermis, surface view. The two kinds of hairs are shown.

Kneiffia fruticosa.—10. Pith and primary wood; medullary phloem groups composed of small thin walled cells. 11. A trichome. 12. Young epidermis. 13. Stereome cells. 14. Epidermis of older part.

Kneiffia glauca.—15. Crystal sac in the pith.

Kneiffia pumila.—16. Transverse section extending from secondary xylem to cortex.

Megapterium missouriensis.—17. Transverse section of the extra-xylar portion.

Oenothera humifusa.—18. Surface view of epidermis. 19. Sclerotic pith cells with unpitted walls. 20. Epidermal and sub-epidermal tissues of young stem. 21 and 22. Emergences. 23. Portion of the common wall between two sclerotic pith cells; intercellular spaces.

Plate XXXVII.

Oenothera humifusa.—24. Sclerotic cells from the pith, showing lamellated structure and pitted walls. 25 and 26. Epidermal hairs.

Oenothera rhombipetala.—27. Intra-xylar phloem island in the secondary wood. 28. Transverse section of a portion of the secondary wood between two medullary rays. 29. An island in the secondary wood seen in longitudinal section. 30 and 31. Trichomes.

Onagra biennis—32. Extra-xylar tissue, transverse section. 33. Diagrammatic cross section of portion of old stem; *e* epidermis, *c* cortex, *s* stereome bundles in the outer portion of the pericycle, *k* cork, *i p* inner pericylic area, *ph* normal phloem, *i* islands in the secondary xylem, *v* vessels of secondary xylem, *w* primary xylem, *m* medullary phloem groups, *p* pith. 34. Portion of a longitudinal section through the secondary xylem, showing a large pitted vessel. 35. Trichomes. 36. Reticulated cells of medullary rays. 37. Spiral and pitted tracheae of the xylem. 38. Epidermis, surface view. 39. Primary and secondary xylem. 40. Part of section of young stem; *p* parenchyma of the cortex, *ed* endodermis, *s* stereome bundles, *k* developing cork. 41. Isolated cells of the pericylic stereome. 42. Pith parenchyma in longitudinal section.

Plate XXXVIII.

Onagra biennis.—43. Hypocotyl of a seedling thirty-eight days old, cross section; *e* epidermis, *p* parenchyma of the cortex, *ed* endodermis, *t t* sieve tubes, *c* cambium, *x* xylem, *pi* pith. 44. Medullary phloem group surrounded by parenchyma. 45. Extra-xylar portion of an old stem, longitudinal section. The periphery of the section is at the left of the drawing where the cork of characteristic structure is seen. 46. Transition from xylem to phloem; a medullary ray is shown terminating in a crystal sac. 47. Intra-xylar phloem islands. 48. Cross section of the hypocotyl of a seedling eight days old. The epidermis, cortex and endodermis are easily distinguished. The various tissues of the stele show but slight differentation. 49. Cross section of young stem previous to cork formation; *e* epidermis, *c* collenchyma, *p* parenchyma of the cortex, *ed* endodermis, *s* stereome bundles, *t* sieve tubes, *m* medullary ray, *c* cambium, *x* xylem.

Figures 43 and 48 are magnified about 600 diameters; the other figures represent a magnification of 200 to 300 diameters.

XLI. A NEW HYPNUM OF THE SECTION CALIERGON.

J. M. Holzinger.

One of the most interesting collecting grounds in southeastern Minnesota is the place designated in my reports as Lamoille Cave. The spot is some twelve miles below Winona, and about a mile below Lamoille, the railroad station The "cave" is produced by the undermining of some ledges of St. Croix sandrock, leaving a low cave a rod or two in extent each way, the sandstone roof meeting the floor all around. A small pool of water covers part of the floor, the effect of a spring in one corner. This water slowly finds its way out into the marshy grassland to the north of the cave, through mats of Anacharis, water speedwell, water cress, the musk plant and their associates. It is in this society, along with its distant relative, Brachythecium rivulare, that the plant under consideration was found in considerable quantity.

Hypnum cyclophyllotum, n. sp.

Plants *dioecious;* dark green above, yellow below; 8–10 c m. high; erect by crowding; stems firm, sparingly beset with small inconspicuous radicles along their entire length. Stem leaves five-ranked, concave, ascending when moist, inclined to be appressed when dry (especially the older leaves, which are also apt to be split part way down from the apex), as broad as long, or *broader*, obtuse, entire margined, costate to apex; costa broad, 100–120 mik. wide, about 30 mik. thick; leaf angles decurrent, strongly excavate, their cells *abruptly* enlarged, hyaline, 25–40 mik. wide, 80–100 mik. long, the thin-walled cells not quite reaching the costa, an area of the small chlorophyllose cells of the body of the leaf passing down on each side of the costa; upper leaf cells 8–10 mik. wide, 40–60 mik. long, chlorophyllose; branch leaves, of the short axillary branches, also concave,

much smaller, the basal auricles less excavate, the costa faint, not extended into the obtuse apex. Antheridial buds numerous along the middle part of the stem, shorter than the leaves, in their axils, with few paraphyses, and perichaetial bracts ecostate. Fruiting plants were not found.

This plant is near Hypnum cordifolium, but differs from this species in having its leaves much more *closely* set on the stem, costate *to apex*, and *much wider* in proportion to length; also in having the larger cells of the auricles *abruptly* enlarged, and the leaf cells proper *smaller*.

It is also near Hypnum giganteum, but differs from it by its unusually broad leaves, its smaller size, dark green color, and fewer branches shorter.

M. Cardot has kindly compared it with the type of Hypnum orbicularecordatum R. & C., and pronounces it a distinct and new species.

Dr. Best has also examined the plant with care, and has aided me by kindly sending, for comparison, specimens of Macoun's Hypnum giganteum, of typical H. cordifolium, and of his own H. cordifolium var. ramosum M S. I cannot, at this time, enter into a detailed criticism of these species and how variously they seem to be understood by different students. I only wish to state, in closing, that, as a result of my study of the number of specimens of Caliergon of North America to which I have had access, I concluded that it would be best to publish the plant under consideration provisionally as a species, rather than as a variety of one of the established species.

There is at hand an abundance of material of this plant, which will be distributed shortly in my third fascicle, Nos. 101–150, of *Mosses of Minnesota*, so that all interested may study it.

Plate XXXIX.

Hypnum cyclophyllotum, Section Caliergon.

Figs. 1, 2, 3. Plants, natural size.
Fig. 4. Piece of stem, enlarged, to show phyllotaxy.
" 5. Stem leaf, x 56.
" 6. Branch leaf, x 56.
" 7. Lower part of stem leaf, x 56.
" 8. Antheridial bud, opened, x 56.
" 9. Cross section of leaf, x 96.
" 10. Leaf of Hypnum cordifolium, x 22.

XLII. CONTRIBUTIONS TO A KNOWLEDGE OF THE LICHENS OF MINNESOTA,—I. LICHENS OF THE LAKE OF THE WOODS.

BRUCE FINK.

It was at first thought best to present in a single paper a full list of all the lichens hitherto collected in the state,—about 200 species. But after looking through these collections it became evident that the state is divided, as regards its lichen-flora, into three or more distinct regions. To give all together would cover up to some extent the distinctive features of each region, and this is not desirable.

The lichen-flora of the portion of the state south of Minneapolis is essentially the same as that of Iowa. But when one examines the lichens found at Taylors Falls, only forty-five miles northeast of Minneapolis, he wonders at the great change in species caused by the peculiar geological formation. The lichens of the Lake of the Woods are, many of them, quite strangers to both of the regions named above. Whether the transition in lichen-flora in passing from Minneapolis to the Lake of the Woods is a gradual one, or occurs quite abruptly at or near the shores of the lake, must be ascertained by a further study of the lichens of the intervening territory. The lichens of the Lake Superior region remain to be studied, and are likely to furnish much that will be interesting.

This paper is an account of collections made during the summer of 1894, by Professor Conway MacMillan and Mr. E. P. Sheldon, and that made by Professor MacMillan in July, 1896, on the American islands. The former collections are the more complete as to localities, but the latter is the more complete in number of species.

The number of species listed is not large, but furnishes several that are interesting because not reported from this portion of the United States before. The genera, *Cladonia, Stereo-*

caulon, *Umbilicaria* and *Physcia* furnish these interesting species, and notes concerning them will be found in the list below. The collection seems to indicate that the species of *Cladonia* are particularly abundant, and the finding of four *Umbilicarias* in this region is not less surprising. It is also worthy of note that two species of *Parmelia* fruit here which do not further south. The notes concerning this fact will also be found below in the list.

In arrangement and synonomy I have followed Tuckerman's Synopsis, which is likely to be the standard for some time in the study of American lichens.

LIST OF SPECIES AND VARIETIES.

1. **Ramalina calicaris** (L.) FR. var. **fastigiata** FR.
On trees. American islands, July, 1896, no. 24.

2. **Evernia prunastri** (L.) ACH.
On wood. Flag island, Aug., 1894, no. 2895. American islands, July, 1896, no. 25.

3. **Usnea barbata** (L.) FR. var. **florida** FR.
On trees. Main land, Huggins landing, July, 1894, no. 1575. Flag island, Aug., 1894, no. 2895*b*.

4. **Usnea barbata** (L.) FR. var. **hirta** FR.
On trees. American islands, July, 1896, no. 27.
Not previously reported from Minnesota.

5. **Usnea barbata** (L.) FR. var. **plicata** FR.
On trees. Flag island, Aug., 1894, no. 2895*c*.

6. **Theloschistes chrysopthalmus** (L.) NORM.
On trees. Garden island, June, 1894, no. 401.

7. **Theloschistes polycarpus** (EHRH.) TUCK.
On trees and dead wood. War Road river, June, 1894, no. 500. Big island, July, 1894, no. 2245. American islands, July, 1896, nos. 10 and 11.
Two distinct forms are placed here, one having a greenish-yellow thallus and yellow apothecia, and the other having fulvous thallus and apothecia. The latter tends toward the next.

8. **Theloschistes lychneus** (NYL.) TUCK.
On trees. American islands, July, 1894, no. 2273. American islands, July, 1896, no. 9.

9. **Theloschistes concolor** (DICKS.) TUCK.
On trees. War Road river, June, 1894, no 500*a*. Garden island, June, 1894, no. 644*a*.

10. **Parmelia borreri** TURN.
On trees. American islands, July, 1896, no. 5.

11. **Parmelia borreri** TURN. var. **rudecta** TUCK.
On trees. American islands, July, 1896, no. 50.
Not previously reported from Minnesota.

12. **Parmelia saxatilis** (L.) FR.
On trees. Main land, Huggins landing, July, 1894, no. 1538. Massacre island, July, 1894, no. 2622. Flag island, Aug., 1894, no. 2895*a*. American island, July, 1896, no. 3.
The plants are frequently fruited, as are several obtained by the writer at Taylors Falls. Further south in Minnesota and Iowa the plant seldom, if ever, fruits.

13. **Parmelia olivacea** (L.) ACH.
On trees. Big island, July, 1894, no. 2245*b*. American islands, July, 1896, no. 6.

14. **Parmelia caperata** (L.) ACH.
On trees. Shoal Lake island, July, 1894, no. 1040 American islands, July 1896, no. 4.

15. **Parmelia conspersa** (EHRH.) ACH.
On granitic rocks. Big island, July, 1894, nos. 2156 and 2182. Massacre island, July, 1894, no. 2616. Island near Northwest angle, Aug., 1894, no. 3224. American islands, July, 1896, no. 2.
Finely fruited here and at Taylors Falls. Further south in Minnesota and Iowa seldom fruited.

16. **Physcia pulverulenta** (SCHREB.) NYL.
On wood. American islands, July, 1896, no. 19.
Not previously reported from Minnesota.

17. **Physcia stellaris** (L.) FR.
On trees and dead wood. War Road river, June, 1894, no. 500*b*. Garden island, June, 1894, no. 644. Big island, July, 1894, no. 2245*a*. American islands, July, 1894, no. 2273*a*. American islands, July, 1896, no. 21.

18. **Physcia tribacia** (ACH.) TUCK.
On trees. American islands, July, 1896, no. 20.
Not previously reported from Minnesota.

19. **Physcia hispida** (SCHREB., FR.) TUCK.

On trees, sterile. American islands, July, 1896, no. 17.

This northern species has not been reported before from central-northern United States. It occurs commonly in New England, and Hall has reported it from Oregon.

20. **Physcia cæsia** (HOFFM.) NYL.

On trees. American islands, July, 1896, no. 51.

21. **Physcia obscura** (EHRH.) NYL.

On trees. American islands, July, 1896, no. 18.

22. **Umbilicaria muhlenbergii** (ACH.) TUCK.

On granitic rocks. Massacre island, July, 1894, no. 2619. American islands, July, 1896, no. 30.

Not previously reported from Minnesota.

23. **Umbilicaria vellea** (L.) NYL.

On granitic rocks. Massacre island, July, 1894, no. 2597.

Not previously reported from Minnesota.

24. **Umbilicaria dillenii** TUCK.

On granitic rocks. Massacre island, July, 1894, no. 2619*a*. American islands, July, 1896, no. 31.

25. **Umbilicaria pustulata** (L.) HOFFM.

On granitic rocks. American islands, July, 1896, no 42.

The last two were listed by the writer as from Wisconsin or Minnesota in Proc. Iowa Acad. Sci. 1894. Otherwise, these four Umbilicarias have not been reported before from central-northern United States.

26. **Peltigera canina** (L.) HOFFM.

On earth. Elmer point, Aug., 1894, no. 2800. American islands, July, 1896, no. 28.

Varying from pretty good forms to the first variety below.

27. **Peltigera canina** (L.) HOFFM. var. **spuria** ACH.

On earth. Shoal lake island, July, 1894, no. 1038. Massacre island, July, 1894, no. 2618. Island near Northwest angle, Aug., 1894, no. 3227.

Not previously reported from Minnesota.

28. **Peltigera canina** (L.) HOFFM. var. **sorediata** SCHÆR.
On earth. Big island, July, 1894, no. 2210.
This plant was often observed by the writer at Minneapolis, where it frequently fruits, as does the plant here listed from the Lake of the Woods. It is rare and usually sterile in Iowa. The plant is nearly as fibrillose beneath as *Peltigera canina* (L.) HOFFM., with shorter always white fibrils, those of the latter frequently becoming brown.
Not previously reported from Minnesota.

29. **Collema crispum** BORR.
On earth. American islands, July, 1896, no. 22.
The margins of the apothecia are crenate, in which the plant is nearer *Collema tenax* (SW.) ACH.
Not previously reported from Minnesota.

30. **Placodium elegans** (LINK.) D. C.
On granitic rocks. American islands, July, 1896. no. 56

31. **Placodium cerinum** (HEDW.) NAEG. and HEPP.
On trees. American islands, July, 1896, nos. 8 and 16.

32. **Placodium vitellinum** (EHRH.) NAEG. and HEPP.
On granitic rocks. American islands, July, 1896, no. 55.
Spores 20 to 30 in asci. Thallus rather deficient, and some of the apothecia have entire margins. In the last two characters the plant approaches var. *aurellum* ACH.
Not previously reported from Minnesota.

33. **Lecanora rubina** (VILL.) ACH.
On granitic rocks. American islands, July, 1896, no. 57.
Not previously reported from Minnesota.

34. **Lecanora varia** (EHRH.) NYL.
On granitic rocks. American islands, July, 1896, no. 52.
Not previously reported from Minnesota.

35. **Lecanora varia** (EHRH.) NYL. var. **symmicta** ACH.
On dead wood. American islands, July, 1894, no. 2273*c*. American islands, July, 1896, no. 29.
The spores are not so wide in proportion to the length as Tuckerman's measurements, as is frequently the case with specimens of various forms of the species from Minnesota and Iowa.
Not previously reported from Minnesota.

36. **Lecanora cinerea** (L.) SOMMERF.

On granitic rocks. American islands, July, 1896, no. 53.

Not previously reported from Minnesota.

37. **Lecanora cinerea** (L.) SOMMERF. var. **gibbosa** NYL.

On granitic rocks. American islands, July, 1896, no. 54.

Not previously reported from Minnesota.

38. **Lecanora muralis** (SCHREB.) SCHÆR.

On granitic rocks. American islands, July, 1896, no. 51.

Not previously reported from Minnesota.

39. **Rinodina sophodes** (ACH.) NYL.

On trees. American islands, July, 1896, no. 15.

Not previously reported from Minnesota.

40. **Gyalecta lutea** (DICKS.) TUCK.

On wood and moss. American islands, July, 1896, no. 1.

Spores rarely three or even four-celled, in which the plant tends toward *Gyalecta friesii* KOERB.

Not previously reported from Minnesota.

41. **Stereocaulon paschale** (L.) FR.

On earth among rocks. Small island south of Little Oak island, July, 1894, no. 1730. Little Oak island, July, 1894, no. 2109. Big island, July, 1894, no. 2154. Elmer point, Aug., 1894, no. 2803. American islands, July, 1896, no. 23.

Not before reported from central-northern United States, except by the writer, in Proc. Iowa Acad. Sci. 1894. The number of collections above prove that the plant is common.

42. **Cladonia cariosa** (ACH.) SPRENG.

On wood. Small island south of Little Oak island, July, 1894, no. 1726*a*. Island near Massacre island, July, 1894, nos. 2437*c* and 2485.

Not previously reported from Minnesota.

43. **Cladonia pyxidata** (L.) FR.

On earth among rocks. Garden island, July, 1894, no. 430. Big island, July, 1894, no. 2153. Massacre island, July, 1894, no. 2603. Island near Northwest angle, Aug., 1894, nos. 3227 and 3287. Flag island, Aug., 1894, nos. 2896 and 2900. American islands, July, 1896, no. 33.

44. **Cladonia fimbriata** (L.) Fr. var. **tubæformis** Fr.

On earth among rocks and on wood. Sweetheart island, July, 1894, no. 299. Small island south of Little Oak island, July, 1894, no. 1729. Little Oak island, July, 1894, no. 2110. Massacre island, July, 1894, nos. 2602 and 2668*a*. Flag island, Aug., 1894, no. 2896*c*. American islands, July, 1896, no 47.

Not previously reported from Minnesota.

45. **Cladonia degenerans** Floerk.

On wood. Garden island, June, 1894, no. 427. American islands, July, 1896, no. 41.

Not previously reported from Minnesota.

46. **Cladonia gracilis** (L.) Nyl.

On earth among rocks. Small island south of Little Oak island, July, 1894, nos. 1723, 1725*b* and 1726. Big island, July, 1894, no. 2243. Island near Massacre island, July, 1894, nos. 2437 and 2484. Flag island, Aug., 1894, no. 2896*a*. American islands, July, 1896, nos. 43 and 45.

47. **Cladonia gracilis** (L.) Nyl. var. **verticillata** Fr.

On earth among rocks. Main land, Huggins landing, July, 1894, no. 1599. Small island south of Little Oak island, July, 1894, nos. 1724 and 1728. Little Oak island, July, 1894, no. 2108. Flag island, Aug., 1894, nos. 2894 and 2899. Island near Massacre island, Aug., 1894, no. 2437*a*. American islands, July, 1896, no. 44.

48. **Cladonia gracilis** (L.) Nyl. var. **hybrida** Schær.

On earth among rocks. Shoal lake island, July, 1894, no. 1041. Small island south of Little Oak island, July, 1894, no. 1723*b*. Massacre island, July, 1894, no. 2598. American islands, July, 1896, no. 40.

Not previously reported from Minnesota.

49. **Cladonia gracilis** (L.) Nyl. var. **elongata** Fr.

On earth among rocks. American islands, July, 1896, no. 48.

50. **Cladonia furcata** (Huds.) Fr. var. **crispata** Fl.

On earth among rocks. American islands, July, 1896, no. 39.

This variety has not been reported before from the interior of the United States.

51. **Cladonia furcata** (HUDS.) FR. var. **pungens** FR.

On earth among rocks. Main land, Huggins landing, July, 1894, no. 1597.

Apparently a rare form in America.

Not previously reported from Minnesota.

52. **Cladonia rangiferina** (L.) HOFFM.

On earth among rocks. Sweetheart island, June, 1894, no. 351. Hill near Rat Portage, July, 1894, no. 920. Island north of Hay island, July, 1894, no. 1961. Big island, July, 1894, nos. 2156 and 2157. Small island south of Little Oak island, July, 1894, nos. 1725 and 1727. Little Oak island, July, 1894, no. 2106. Massacre island, July, 1894, nos. 2568 and 2601. Island near Northwest angle, July, 1894, nos. 3222, 3286 and 3289. Elmer point, Aug., 1894, no. 2805. American islands, July, 1896, no. 37.

53. **Cladonia rangiferina** (L.) HOFFM. var. **alpestris** L.

On earth among rocks. Sweetheart island, July, 1894, no. 350. Small island south of Little Oak island, July, 1894, nos. 1725*a* and 1729*a*. Little Oak island, July, 1894, no. 2107. Massacre island, July, 1894, no. 2600. Elmer point, Aug., 1894, no. 2804. Island near Northwest angle, Aug., 1894, no. 3223. Flag island, Aug., 1894, no. 2898. American islands, July, 1896, no. 35.

Not previously reported from Minnesota.

54. **Cladonia uncialis** (L.) FR.

On earth among rocks. Island north of Hay island, July, 1894, no. 1962. Little Oak island, July, 1894, no. 2111. Massacre island, July, 1894, no. 2599. Big island, July, 1894, no. 2155. Flag island, Aug., 1894, no. 2897. American islands, July, 1896, nos. 34 and 36.

Not previously reported from Minnesota.

55. **Cladonia cornucopioides** (L.) FR.

On earth among rocks. Main land, Huggins landing, July, 1894, no. 1599.

Not previously reported from Minnesota.

56. **Cladonia macilenta** (EHRH.) HOFFM.

On dead wood. American islands, July 1896, no. 46.

Not previously reported from Minnesota.

57. **Cladonia cristatella** Tuck.

On dead wood. Sweetheart island, June, 1894, no. 298. Main land, Huggins landing, July, 1894, no 1593. Small island south of Little Oak island, July, 1894, no. 1726*b*. Big island, July, 1894, no. 2213. Flag island, Aug., 1894, nos. 2893, 2894*a* and 2896*b*. American islands, July, 1896, no. 38.

58. **Biatora atropurpurea** (Mass.) Hepp.

On bark of Populus. American islands, July, 1896, no. 13.

Thallus thin, membranous, whitish, becoming scurfy; apothecia rather small, adnate, disk a little convex and becoming somewhat rough, pale within. Spores ellipsoid, simple, $\frac{12-18}{4-5}$ mik, 8 in asci.

The plant is placed here provisionally.

Not previously reported from Minnesota.

59. **Biatora rubella** (Ehrh.) Rabenh.

On trees and dead wood. American islands, July, 1896, no. 12.

Spores $\frac{45-66}{3-4}$ mik, the longest being 10 mik. longer than Tuckerman's measurements, as are those of the European plant.

Not previously reported from Minnesota.

60. **Lecidea enteroleuca** Fr.

On trees. American islands, July, 1894, no. 2273*b*.

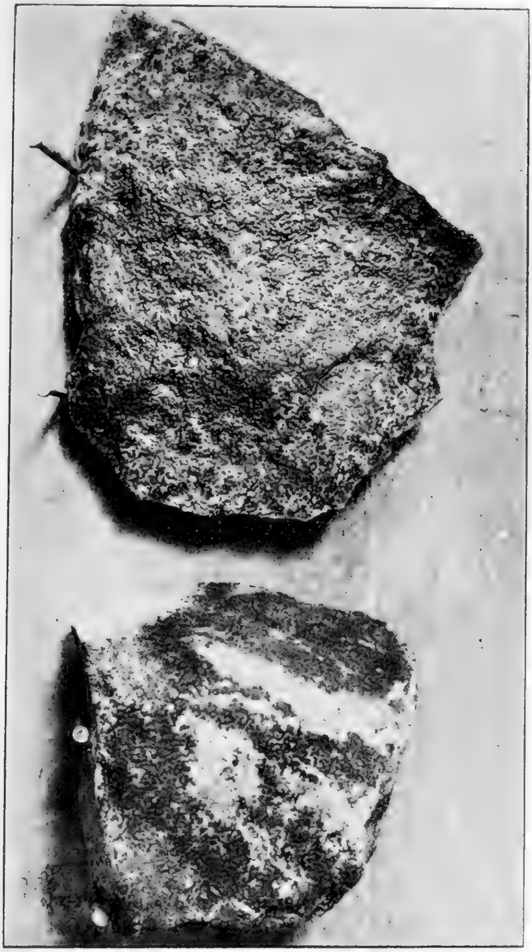
61. **Buellia parasema** (Ach.) Th. Fr.

On trees. American islands, July, 1896, no. 14.

62. **Endocarpon fluviatile** DC.

On submerged rocks. Massacre island, July, 1894, no. 2622*a*. American islands, July, 1896, no. 26.

Not previously reported from Minnesota.



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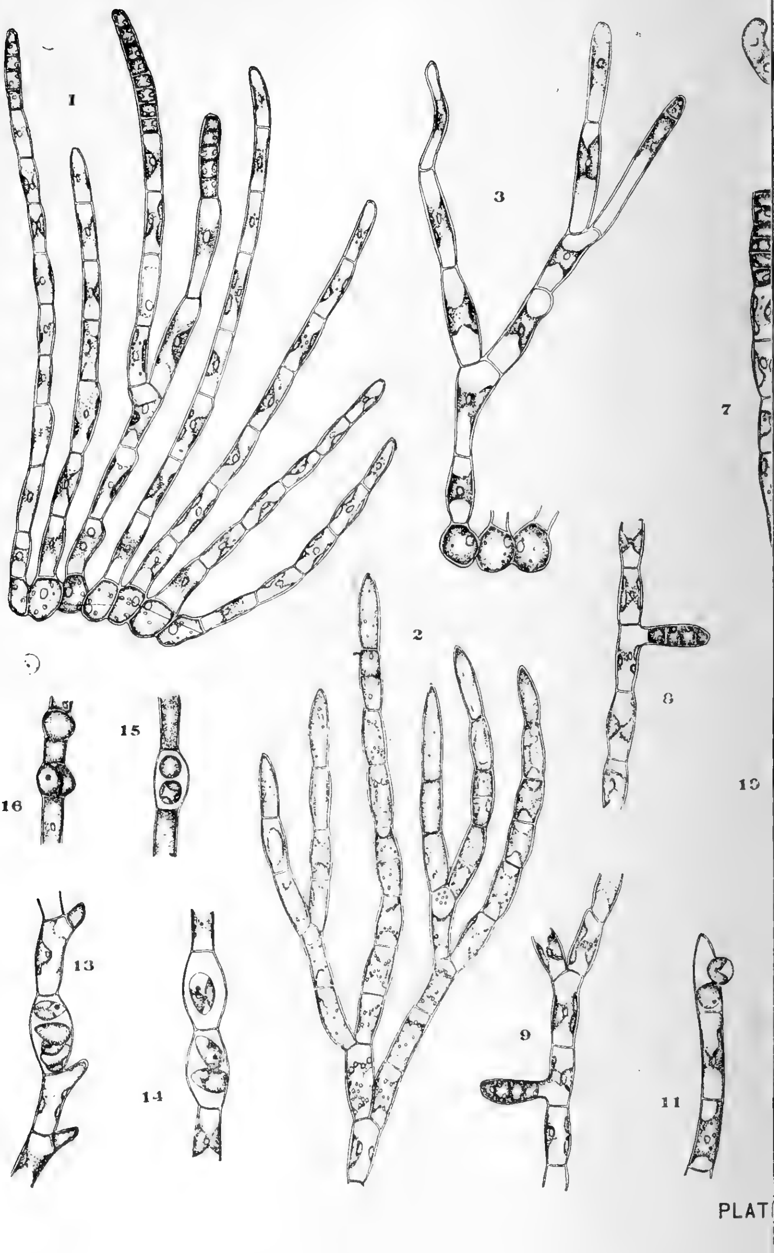

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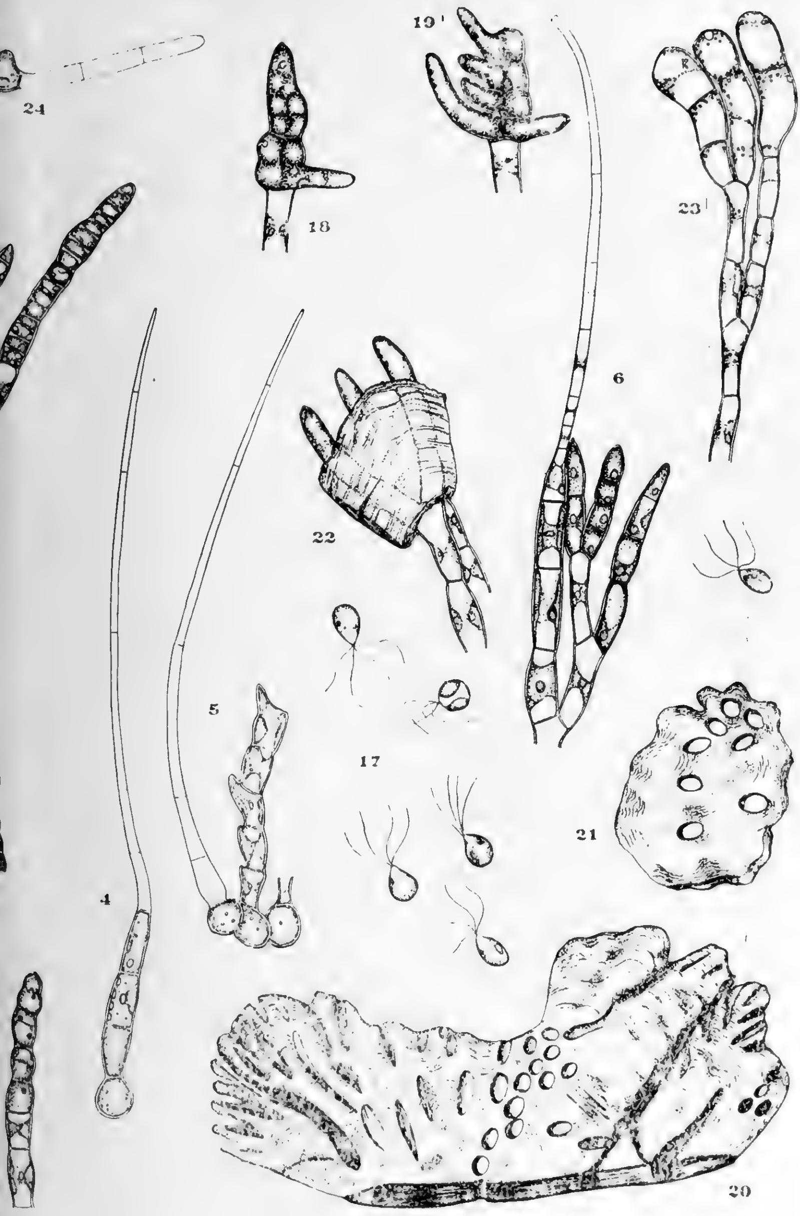

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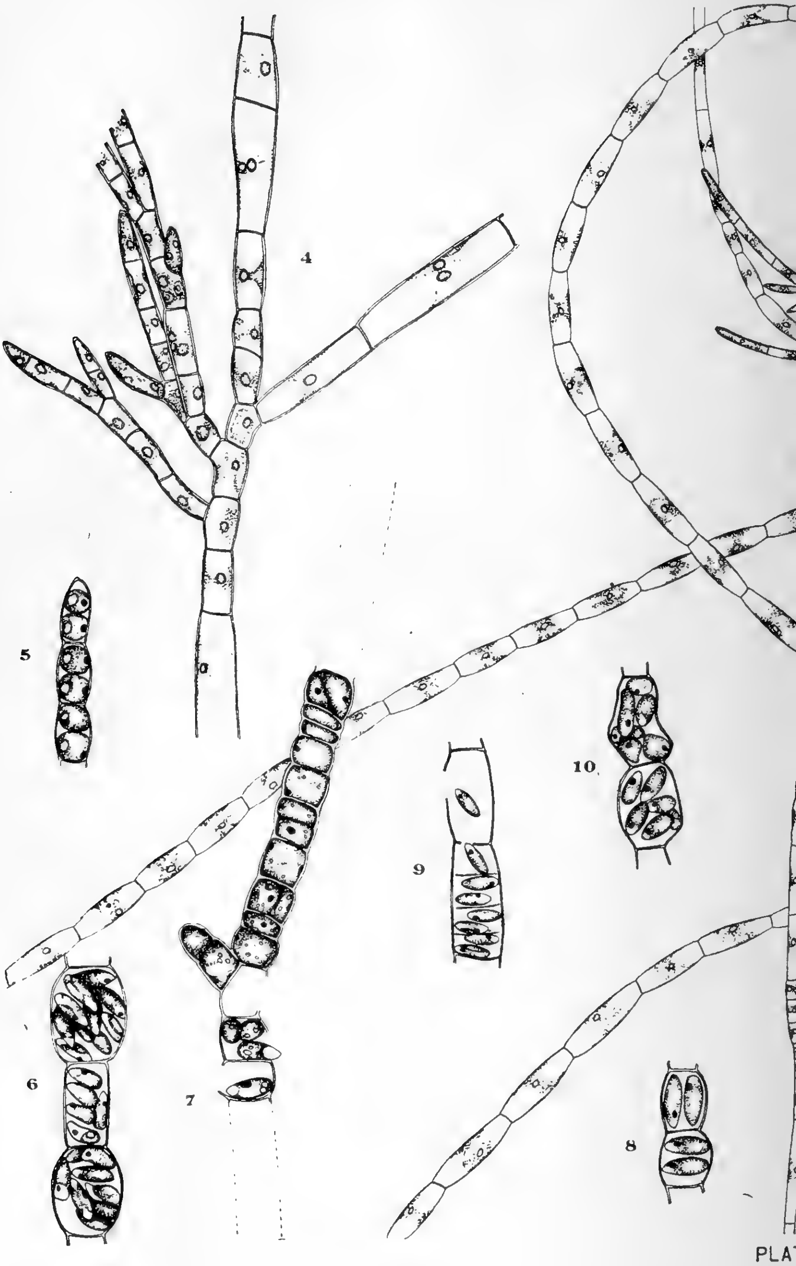

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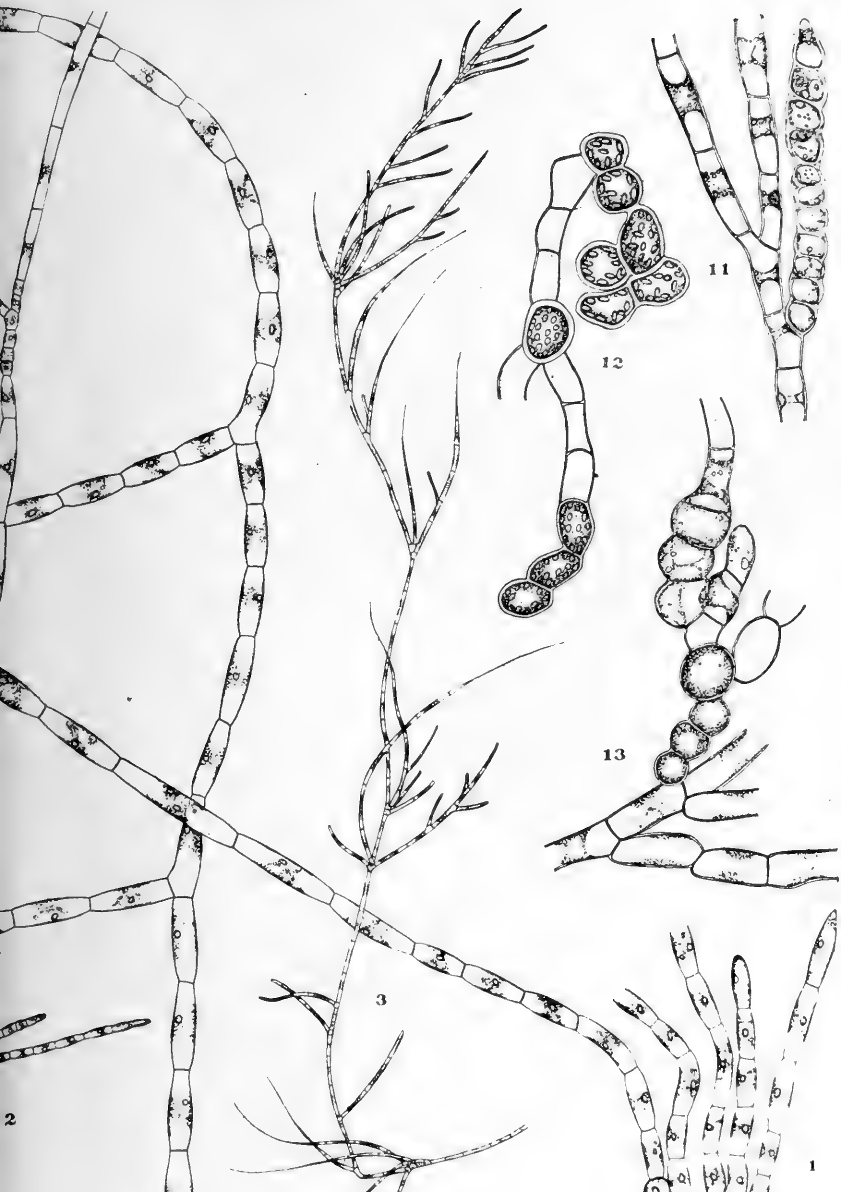

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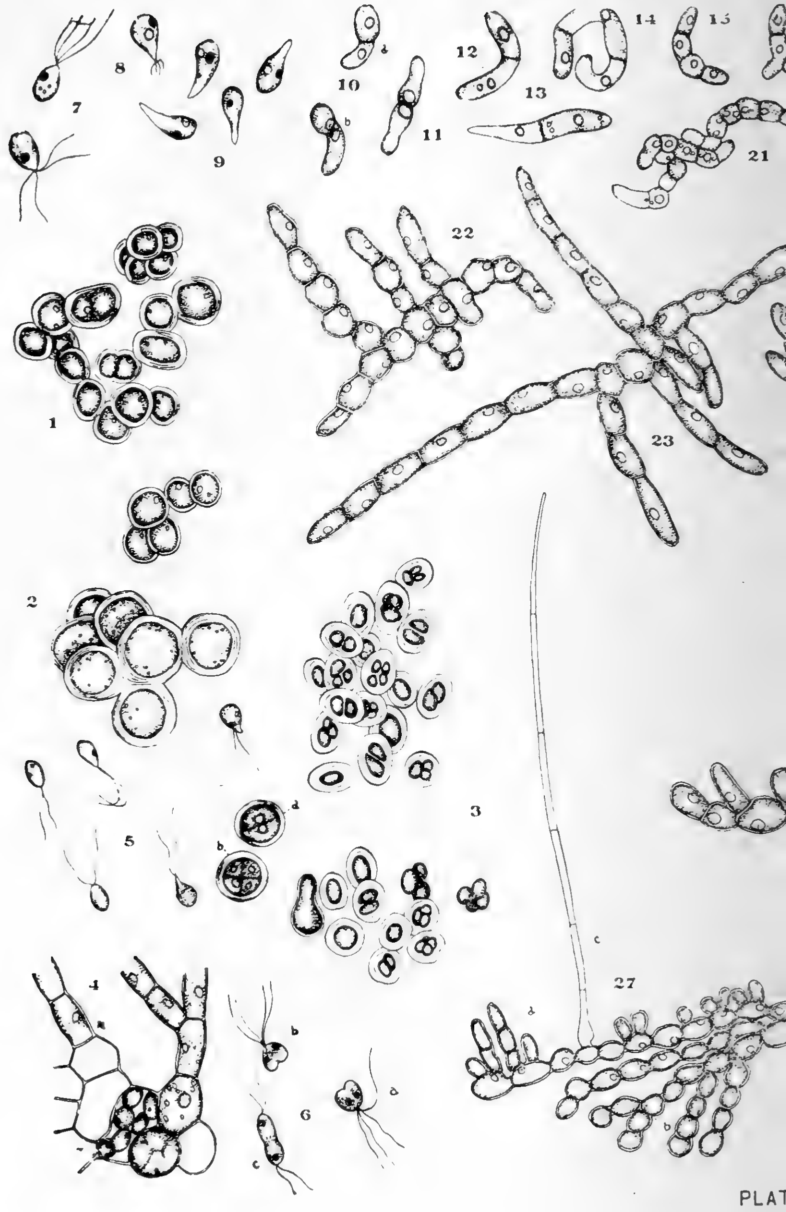

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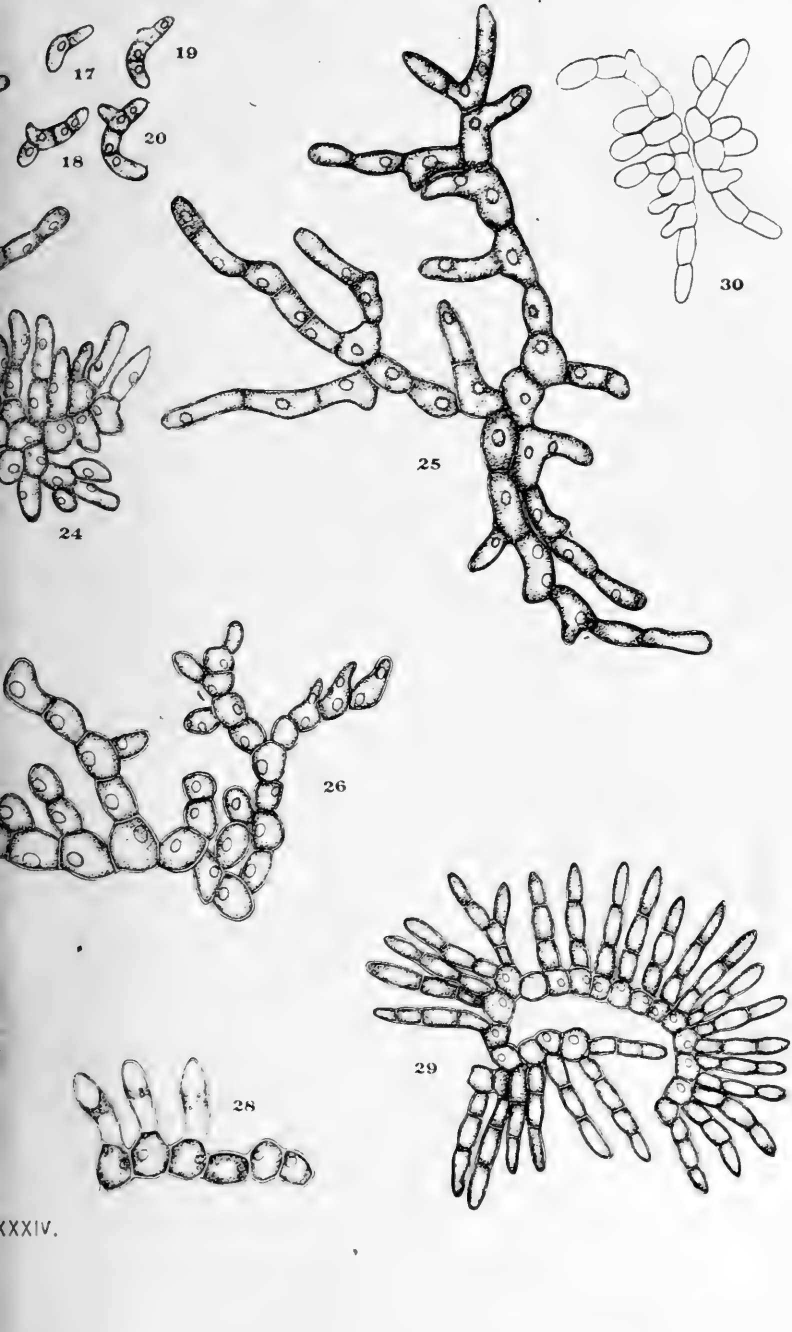

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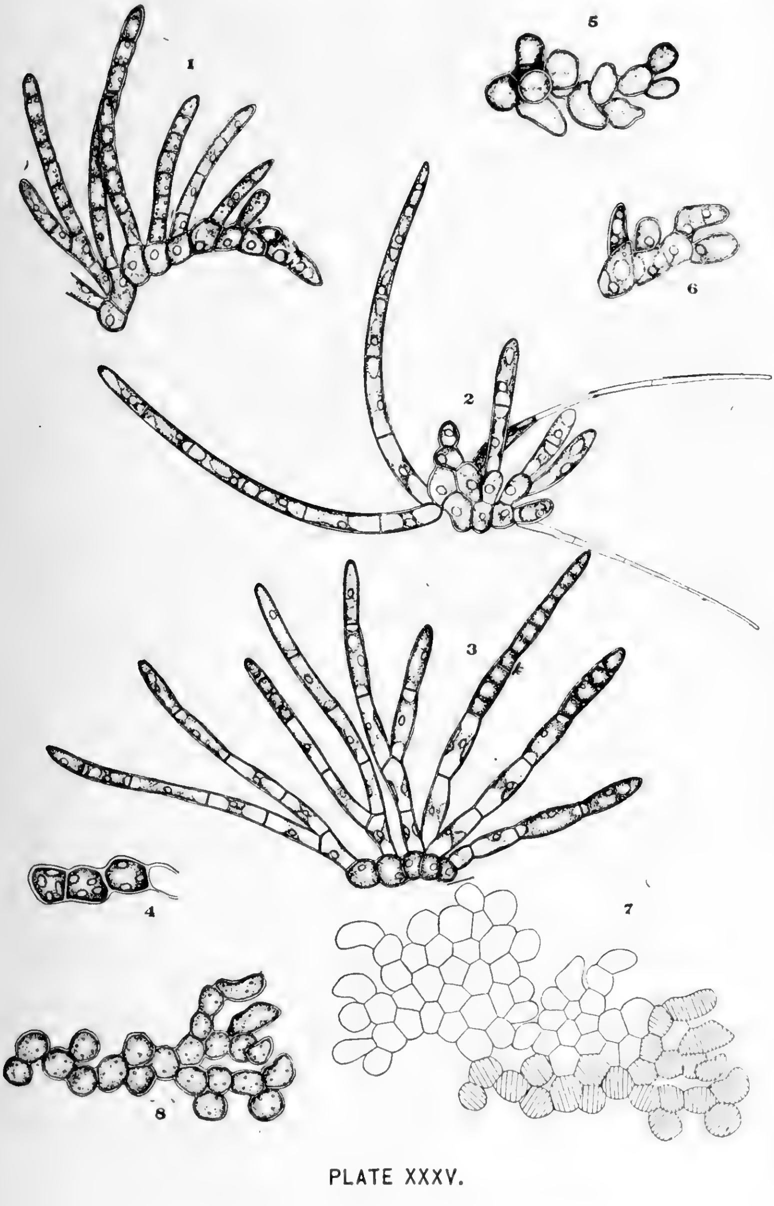

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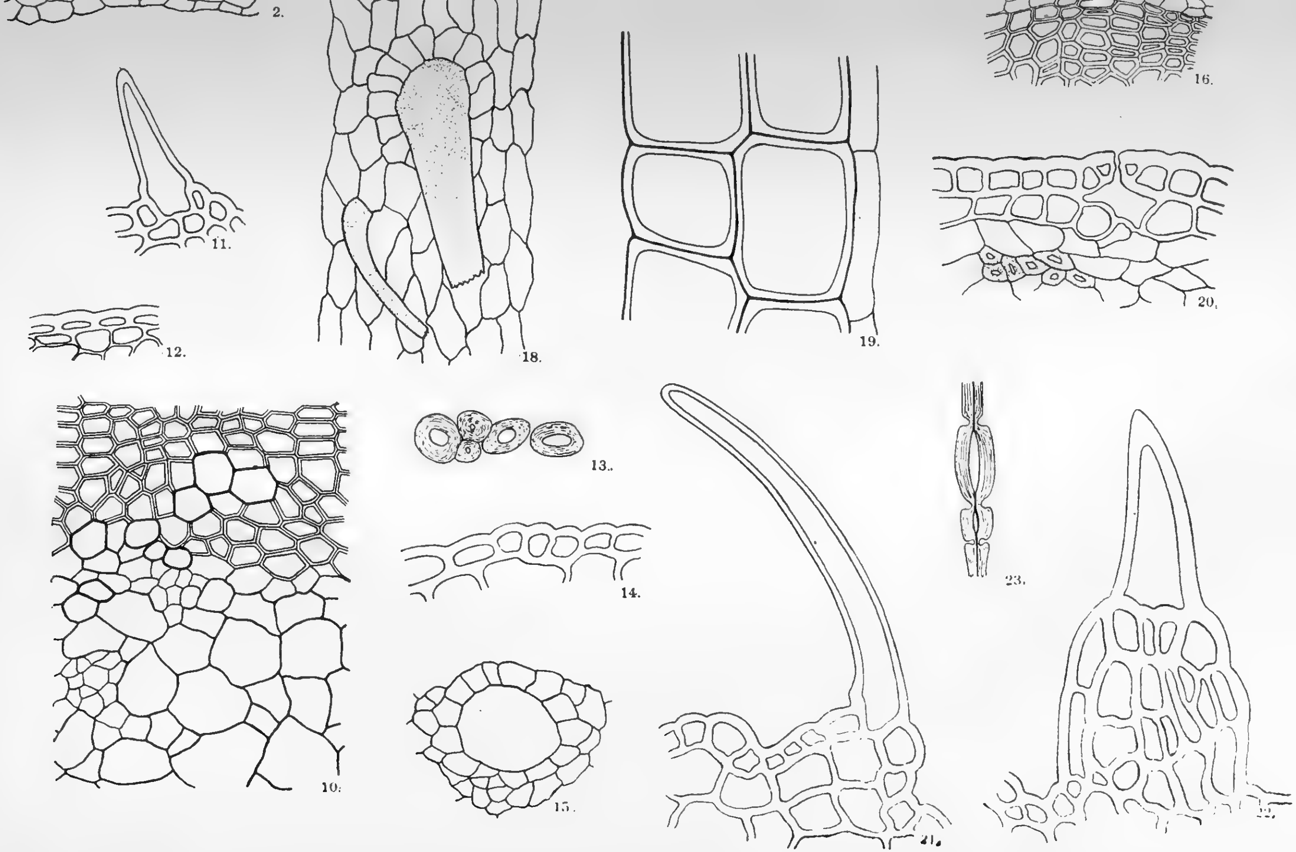

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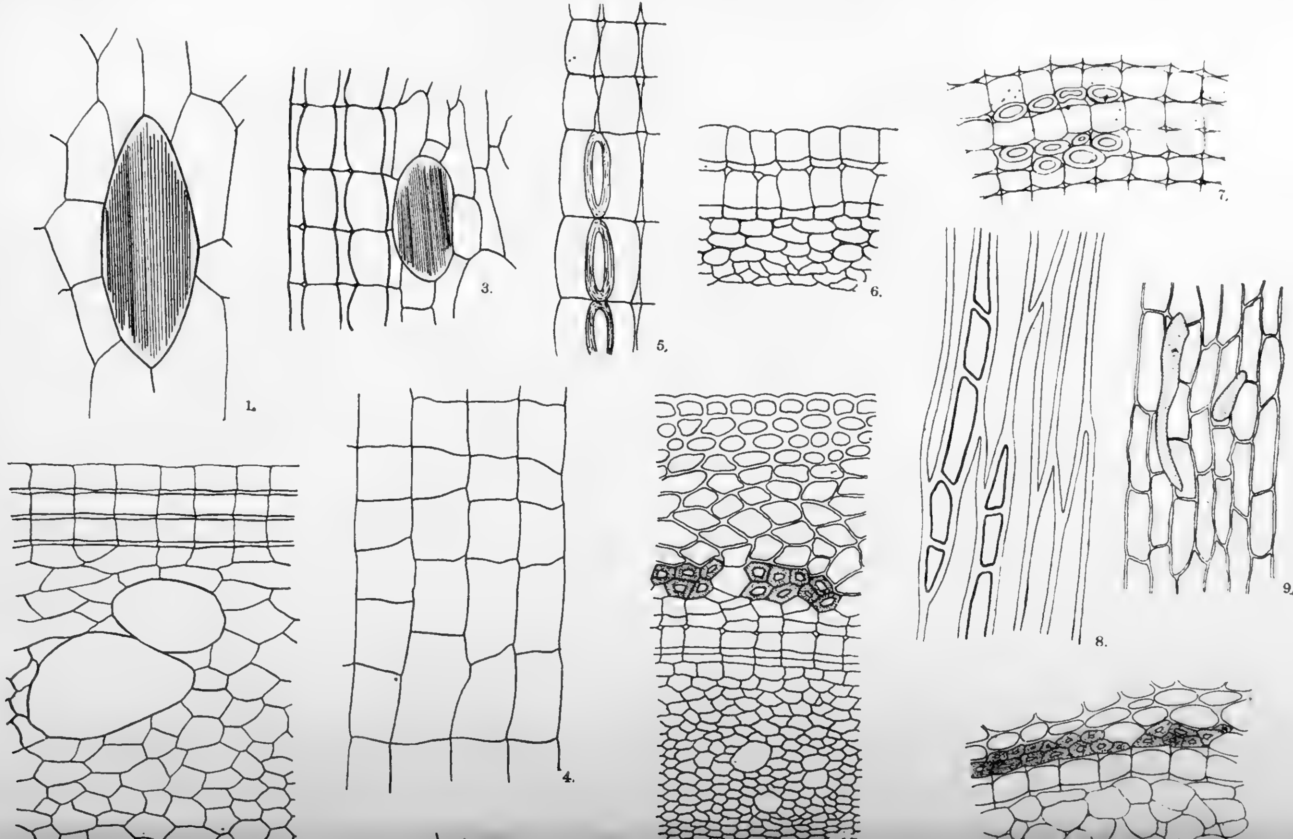
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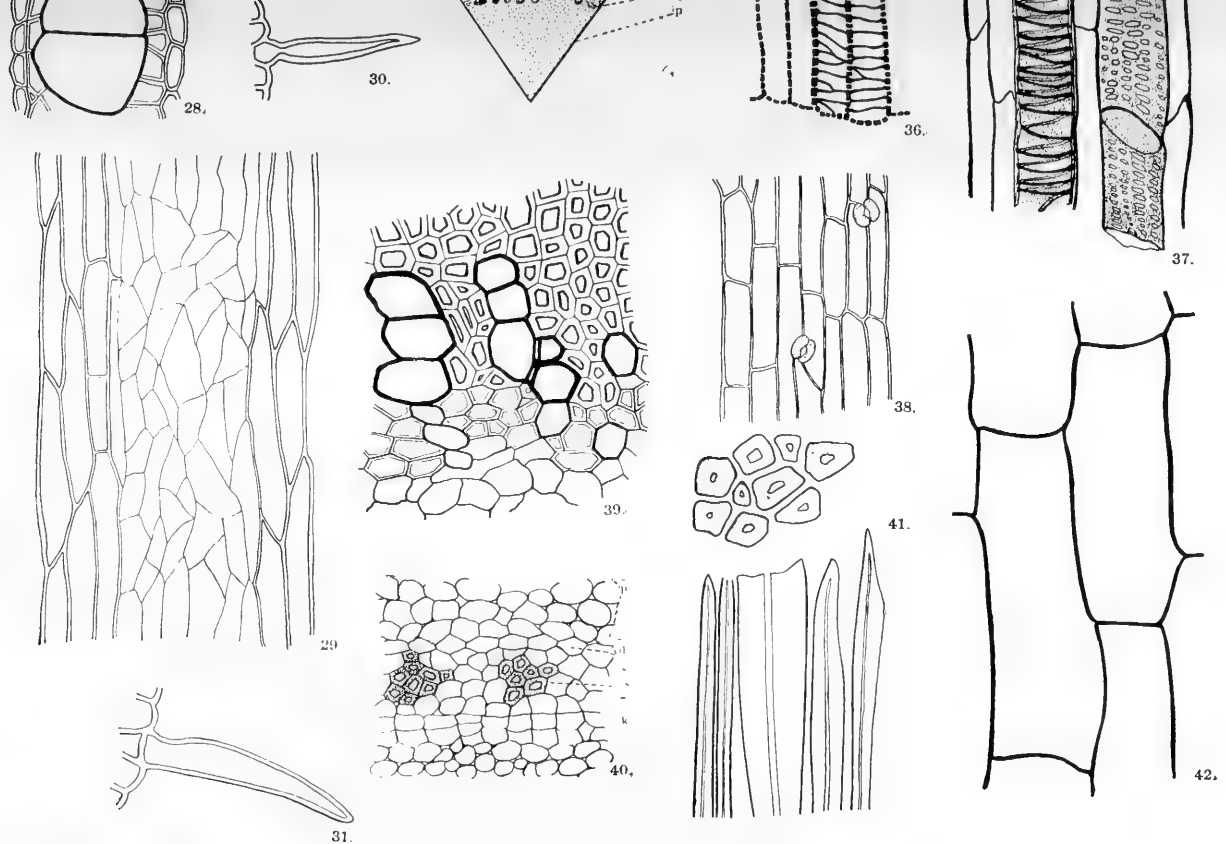

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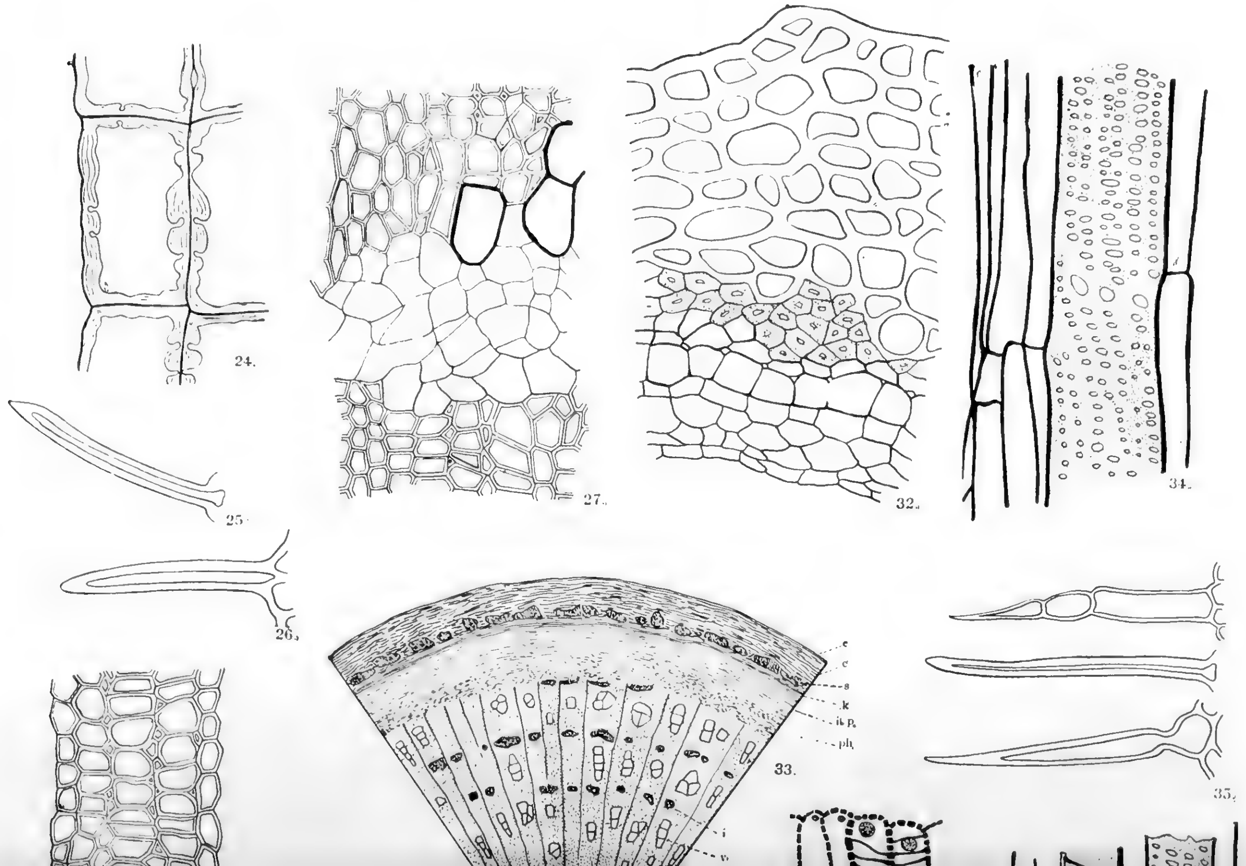
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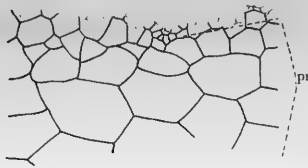

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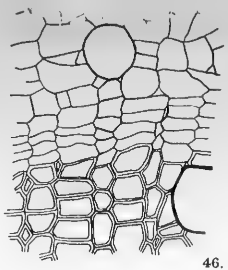

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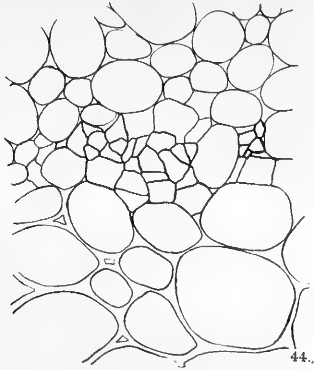

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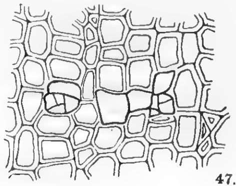

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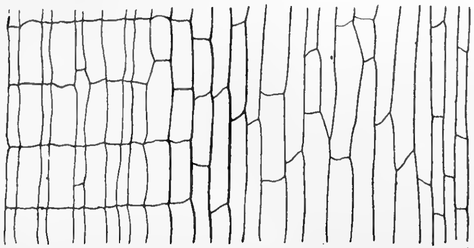

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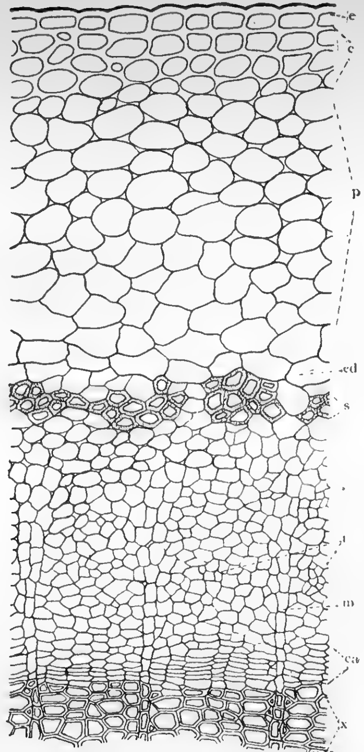

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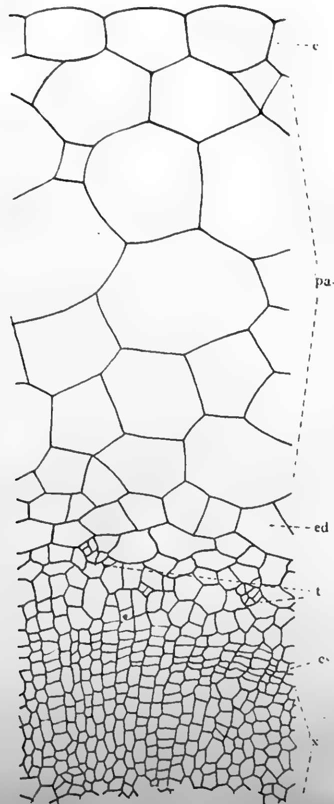

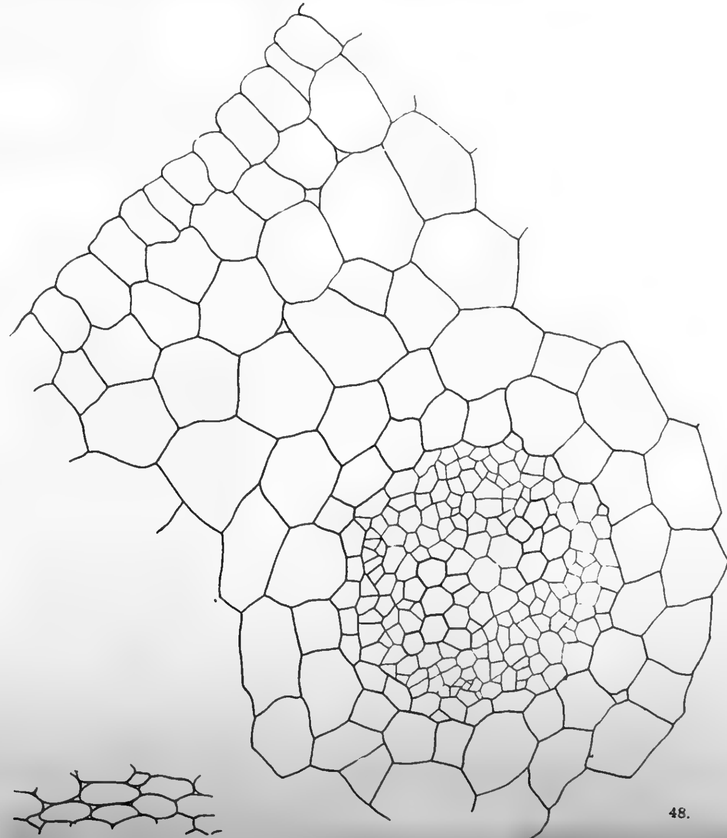

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PLATE XXXIX.

XLIII. CONTRIBUTIONS TO A KNOWLEDGE OF THE LICHENS OF MINNESOTA—II. LICHENS OF MINNEAPOLIS AND VICINITY.

BRUCE FINK.

CONSIDERATIONS OF DISTRIBUTION AND HABITAT.

This paper is based upon collections made by me during the summer of 1896 in the outskirts of Minneapolis, or within six miles of the city limits. As stated in the preceding paper, the lichen-flora of that portion of Minnesota from Minneapolis south is essentially similar to that of northern Iowa. After having worked over portions of this latter area thoroughly, I was quite as much interested while collecting at Minneapolis to ascertain how the two regions bordering on the Mississippi river compared with reference to their lichen-floras as in questions purely local. Indeed, in no way can plant-distribution be studied better than by comparing different areas, and I shall attempt to draw some conclusions, from my study of certain localities, concerning lichen-distribution in the region now under consideration.

The first thing that impressed me in the study of the region about Minneapolis is that lichens are not so numerous there either as regards species or individuals as in some other parts of Minnesota, or in certain equal areas in northern Iowa. I have made a collection of about 220 species at Fayette, Iowa, of which 180 species were listed in my paper upon the lichens of Iowa. These numbers are given for the whole county of Fayette, but, for purposes of comparison, all species not within five miles of the city of Fayette are cut out, as will appear in a table to follow.

The only noteworthy differences between the vicinities of Minneapolis and Fayette as regards substrata suited to lichen-development are the presence of the Saint Peter sandstone at

the former place, which does not occur at the latter, and the fact that the paleozoic limestones outcrop at the surface much more frequently at the latter. The first difference is in favor of the lichen-flora about Minneapolis, and the second favors that about Fayette, as each of these substrata bears its characteristic lichens. As will be especially noted toward the close of these notes, these two differences about offset each other. The tamarack swamps about Minneapolis have no parallel about Fayette and furnish lichens not found, or rare, in other parts of the region considered in this paper. Yet all of these lichens occur about Fayette on one substratum or another, so that, in the comparison, the former region will gain nothing. Minneapolis has the larger river and the lakes, but not a single lichen has occurred near these bodies of water that is especially characteristic of such localities. However, these bodies of water give the region a peculiarity of lichen-distribution which can scarcely escape the notice of an experienced collector. It is that the number, both of individuals and species, is noticeably greater about the lakes and river than in places somewhat remote from them.

The following table, giving the genera and the number of species in each for the Minneapolis and Fayette vicinities, will be instructive and will form the basis for some further comparisons of the two regions.

GENERA.	No. of species, Mpls.	No. of species, Fayette.	GENERA.	No. of species, Mpls.	No. of species, Fayette.
Acolium	1	1	**Opegrapha**	1	2— 2
Arthonia	3	5— 1	**Pannaria**	2	2— 1
Alectoria	1	1	**Parmelia**	8	9— 1
Biatora	6	13— 3	**Peltigera**	6	6
Buellia	3	5— 1	**Pertusaria**	3	4— 2
Cetraria	1	1	**Physcia**	10	10— 1
Cladonia	9	16	**Placodium**	10	10— 1
Collema	2	7— 1	**Pyrenula**	4	7— 1
Coniocybe	0	1	**Pyxine**	0	1
Endocarpon	5	6	**Ramalina**	3	3
Evernia	1	1	**Rinodina**	3	4
Gyalecta	0	0— 1	**Staurothele**	0	1
Graphis	1	2— 1	**Theloschistes**	4	5
Heppia	0	1	**Urceolaria**	1	1— 1
Lecanora	15	16— 2	**Usnea**	4	4
Lecidea	1	2— 1	**Verrucaria**	3	4— 1
Leptogium	1	5			
Omphalaria	1	1— 1	Totals	113	157—23

The collecting at Fayette extended over three years, and that at Minneapolis only over two months. Yet the collecting at the former place was my first extended work on lichens, and the best part of the work was confined to a single summer.

The Fayette column I have divided into two parts, the first containing 157 species, which, with present experience, I should expect to find in a region as favorable for lichen-development as Fayette and in the time spent in collecting at Minneapolis. The second part of the Fayette column contains 23 species, so rare that one would not be so likely to find them in the short time, or which are not found within five miles of Fayette. The 113 species found at Minneapolis are about 72 per cent of the 157 species of Fayette lichens, and it will be an approximately correct estimate to say that lichens are one-fourth more numerous at the latter place than at the former.

The cause of the smaller number of lichens about Minneapolis is evidently to be sought mainly in its dryer climate. Several considerations have conspired to cause me to arrive at this conclusion. First, most species of lichens here are more disposed to confine themselves to moist situations, as about the bodies of water mentioned above, in heavy woods, or when in dry places near the ground. The last tendency is noticeable in *Graphis scripta* (L.) ACH., which in dry places most frequently grows low down on the trunks of the trees. In passing up from the Mississippi river banks 50 to 100 feet to the level ground just above the bluffs the decrease in number of species and individuals, whether on rocks, earth or trees, is very striking. In one place within or near the city limits the granitic boulders just above the bluffs are well covered with lichens, while twenty rods back from the river in open ground the rocks of the same kind are nearly bare of them. The decrease is not so marked in lichens growing on trees as in those growing on rocks, but is noticeable. I am not referring now to change in species in passing to the dryer locality, which also occurs here as elsewhere, and is due to stress caused by environment. Further, it may be said that a decrease would occur in numbers in other regions, but observation shows it to be more marked in dry climates. In parts of northern Iowa no such noticeable decrease occurs. Here 15 or more species of lichens may easily be found on a single tree in moderately dry situations, and nearly all the species commonly occurring on the boulders in the vicinity of Fayette may be found on a single one in an open dry field far removed from any stream.

Second, the gelatinous lichens, which thrive in moist places, are rare at Minneapolis. The first table will show that the genera *Collema* and *Leptogium* show 3 species at Minneapolis and 12 at Fayette. I took special pains to investigate this

peculiarity of distribution at the former place, searching deep wooded ravines where these species should abound. It may be added that two of the three species given for the one locality are much rarer than any one of the 12 given for the other. This adds to the evidence in a way not shown in the table.

Third, the genus *Peltigera*, the species of which grow on the ground where they can get an abundance of moisture, is represented by an equal number of species in the two localities compared, as will appear upon examining the first table. The individual *Peltigeras* are also about equally numerous in the two regions, the genus *Peltigera* being probably the best developed one of the flora about Minneapolis, though several other genera are represented by more species.

A thorough exploration of three or four selected areas along the Mississippi river, between the two localities compared above would, if made by one well acquainted with lichens and their habits of growth, bring out some very interesting and instructive information regarding lichen-distribution. The first and second questions considered just above could thus be traced. As to where the gelatinous lichens decrease in number most rapidly in passing northward; and where the change from comparative uniformity of distribution, so far as influenced by the moisture or dryness of small adjacent areas, to greater lack of uniformity in this regard takes place most rapidly, are questions of interest.

The difference in number of species of lichens for the two localities compared is a greater per cent of the larger total than is the difference in number of genera. Fayette has 34 genera and Minneapolis 29. The difference in favor of the former place for genera is only 15 per cent, while for species it is about 28 per cent, or nearly twice as great. Reference to the table will show that the five Fayette genera (*Coniocybe*, *Gyalecta*, *Heppia*, *Pyxine* and *Staurothele*), not thus far found at Minneapolis, are each represented at the former place by a single species Hence, the 15 per cent has not the significance that it would have if it stood for genera well represented at one place and wanting at the other. On the whole, the less favorable conditions for lichen development have affected the number of species vastly more than the number of genera.

Further knowledge of the distribution of the lichens about Minneapolis can be gained by the consideration of the table below, in which I have given numbers of lichens for various substrata for Minneapolis and Fayette with the per

cents which these numbers represent of the whole number of lichens found in each locality on the substrata considered.

SUBSTRATA.	No. and per cent, Minneapolis.	No. and per cent, Fayette.
Wood	58 or 58.5 per cent	90 or 57 per cent.
Calcareous rocks	17 or 17+ "	31 or 19.33 per cent.
Granitic rocks	12 or 12+ "	17 or 10.66 "
St. Peter sandstone	5	0
Earth	12 or 12+ per cent	22 or 13.75 per cent.
Wood and rocks	5	15
Wood and earth	1	2
Rocks and earth	3	3
Total numbers	113	180

The table shows very little difference in the per cents of species on different substrata for the two localities, and this would seem to indicate that, though the dryer climate of the Minnesota region has caused a poorer development of lichens than is found at the Iowa locality, it has not caused these plants to seek substrata especially favorable for their development. Other factors enter in to compensate differences which would otherwise occur to such an extent that the table shows in this respect just what it would not show were it not for these factors,—similarity as to number of lichens on different substrata for the two regions.

These other factors have prevented the development of a larger per cent of earth and rock lichens. As climate becomes dryer the relative per cent of these lichens should increase because nearer the earth there is more moisture. First as to the lichens on calcareous rocks, the per cent for Fayette is a little higher than that for Minneapolis, while the opposite condition should follow the difference in climatic conditions between the two places. This apparent difficulty is easily explained since the calcareous rocks outcrop at the surface much more frequently at the former locality. The lichen-species on calcareous rocks at Minneapolis are those confined in both places to perpendicular exposures, while one-third of the species found at Fayette are characteristic of surface outcrops. Deducting one-third of the 19.33 per cent given in the table for Fayette leaves less than 12.7 per cent and gives Minneapolis an advantage of more than 3 per cent for conditions as to substrata existing at both places. This is given as the true relation so far as influenced by the difference in hygrometric conditions.

Next as to the lichens on granitic rocks, the difference of 1.3 per cent in favor of Minneapolis is not so great as might be expected. This is due to the fact that so many of the granitic boulders are in dry open places. The few in moist or shaded places are reasonably well covered with lichens, but those not thus protected are not, as has been stated elsewhere. The limestone exposures are usually shaded along the wooded river banks, hence the advantage for these rocks would be greater than for the granitic rocks were it not for the lack of surface outcrops of the limestone rocks.

As to the earth lichens, the region including Minneapolis lacks the calcareous-earth lichens of the Iowa region, because the calcareous rocks are more deeply covered by drift and have not been so frequently exposed to help in soil formation. Of the 22 earth lichens found at Fayette 7 occur on calcareous earth, while of the 12 found at Minneapolis only 2 occur on calcareous earth. Reducing the first number to 15 and the third to 10 gives Minneapolis an advantage of .3 per cent. This .3 per cent does not show the effect of atmospheric differences between the two places compared, because of the Minneapolis *Cladonias* only one-third occur on the earth, while of those at Fayette about two-thirds grow on the ground. Since I shall be able to present no very satisfactory explanation of this difference in distribution of the *Cladonias*, it might be fair to throw the earth *Cladonias* out of the calculation; and, if this were done, the advantage in favor of Minneapolis in the per cents would be about 2.5.

As to the wood lichens about Minneapolis, it will be seen that if the per cents of rock and earth lichens were what we should expect from hygrometric conditions alone, the per cent of these would rise and that of the wood lichens would fall in comparative proportion. In other words, conditions other than atmospheric have tended to decrease the rock and the earth lichens, but not the wood lichens. Scarcity of lichens on trees removed from the large bodies of water and not in heavy forests has been noted elsewhere in this paper. As to lichens on dead wood, especially old boards, the Minneapolis region furnishes 8 and Fayette 14. The per cent of the whole lichen-floras in favor of the latter region is about one. In the Minneapolis region the lichens on old boards are common enough in damp places, but in dry ones old boards are frequently quite bare of them. In the Iowa region the old boards are abundantly supplied with lichens, even in dry places.

The reconstructed table below (which leaves the numbers of lichens for the substrata considered unchanged in the Minneapolis column except that for the earth lichens all calcareous-earth lichens plus all earth *Cladonias* are omitted, treats the Fayette earth lichens in the same way and also deducts from the latter column all the calcareous-rock lichens found on surface exposures) gives the relative per cents for all the substrata considered as influenced by atmospheric conditions alone.

SUBSTRATA.	No. and per cent, Minneapolis.	No. and per cent, Fayette.
Wood	58 or 62.3+ per cent	90 or 68+ per cent.
Calcareous rocks	17 or 18.25— " "	20 or 15+ " "
Granite rocks	12 or 12.8+ " "	17 or 12.8— " "
Earth	6 or 6.5— " "	5 or 4— " "

This table simply places the per cents that would result from atmospheric conditions where they may be easily compared. However, by the reduction of the numbers representing earth and calcareous-rock lichens to eliminate other causes, it reduces the advantage for the Minneapolis vicinity in granitic rock species to a very small fraction. A somewhat larger number of such rocks were examined about Fayette, and possibly the larger number increases the number of species of lichens on them, which once established may now all be found on a few of the rocks. However, if the smaller number about Minneapolis is due to removal of the rocks, this argument loses much of its value. This table shows the relation between the wood lichens, as influenced by climate alone by per cents, which has not been done before.

I have already stated that the comparative numbers of lichens for Minneapolis and Fayette apply for individuals as well as for species. Now, it must not be supposed that earth and rock lichens are comparatively common at the former place because the per cents are higher. A careful inspection of the tables will show that this does not follow. There are only a few lichen species which may be regarded as comparatively common about Minneapolis, such as most of those occurring on the Saint Peter sandstone, some of the *Peltigeras*, one or two *Endocarpons*, *Rinodina sophodes* (ACH.) NYL., *Physcia stellaris* (L.) TUCK. and perhaps two or three others. I have attempted to state in the list whether the species are common, frequent, or rare, and it seems to me that the number of rare lichens is large. This is very noticeable in the *Lecanoras* where only one species of 15 listed is given as common.

The Saint Peter sandstone along the Mississippi river near Minneapolis, and that along the same river in northeastern Iowa near McGregor, may be compared as to lichen-floras by use of the following table, which gives the species characteristic of these rocks in both places, and also those found on them in each place and not in the other.

Species found in both places.	In northeastern Iowa only.	About Minneapolis only.
Ramalina calicaris (L.) FR. var. **farinacea** SCHÆR.	**Pannaria microphylla** (SW.) DELOS.	**Cladonia cæspiticia** (PERS.) FL.
Urceolaria scruposa (L.) NYL.	**Cladonia rangiferina** (L.) HOFFM. var. **sylvatica** L.	
Cladonia cornucopioides (L.) FR.	**Cladonia uncialis** (L.) FR.	
Usnea barbata (L.) FR. var. **rubiginea** MICHX.	**Biatora granulosa** (EHRH.) POETSCH.	

This table affects comparisons thus far made in no way since the Iowa locality, now under consideration, is a different one than that previously used. In all the comparisons thus far made, the lichens on the Saint Peter sandstone have been eliminated with those of other substrata occurring in only one of the localities. Now, in the above table it will be noticed that the Iowa region has the advantage in the number of species not common to both. Knowing what occurs in Iowa, I examined the Minnesota locality very carefully, and the advantage is apparently due to the more favorable conditions for lichen growth in northern Iowa. The four species common to both regions are doubtless distributed along the river between the two localities wherever these rocks are exposed. How far north the four species found only in the Iowa locality extend, and how far south that found only in the Minnesota locality extends, are questions of interest. Knowledge on this point might lead to a modification of views just stated.

Usnea barbata (L.) FR. var. *hirta* FR., is also confined to the Saint Peter sandstone at the Minnesota locality, but not at the Iowa one, though occurring on this formation there also. This rock is apparently its most natural habitat in the regions considered, to which habitat it is confined in the one less favorable to lichen development. Though, as in this instance, I have omitted from the last table the species found on these rocks and also on other substrata near by in one or both regions, abruptness in floral change due to stress caused by change in substrata is seldom better illustrated than in comparing the lichens

of the Saint Peter sandstone with those of other substrata that happen to lie adjacent. The distribution of lichens on this rock formation in Minnesota, Wisconsin, Iowa and Illinois is worthy of careful study. Other questions of distribution would be brought to light, illustrated by the species here considered and doubtless by several others not yet collected on these rocks.

The statements thus far made will surely lead to some wrong conclusions on the part of readers if not somewhat explained. A perusal of the foregoing comparisons might lead to the conclusion that the region covered by this paper is poorer in lichen-species than it really is. It has been compared with a region probably as much above the average for the part of the upper Mississippi valley near the river as it is below as to number of lichens, and yet the per cent of difference in favor of the Iowa locality is only 28.

On the other hand, comparison with some other lists of lichen-floras about large cities might cause one to conclude that I have omitted certain factors that tend to decrease the number of species for such regions and have been at error in asserting that the locality treated in this paper is not naturally up to the average in number of lichens. For instance, the recent list by Mr. W. W. Calkins, for Chicago and vicinity, covering a much larger area than the one treated in this paper, only contains 12 more species. Probably Mr. Calkins' collecting was as well done as mine, but from personal knowledge, as well as from the statement of Mr. Calkins in his introduction, I know that the Chicago region, naturally not a rich lichen-area, is now not so rich as formerly because of the inroads of civilization destroying substrata. Destruction of substrata need scarcely be considered in the area about Minneapolis, for, excepting perhaps the granitic boulders, one can find as great an abundance of substrata about Minneapolis as about Fayette, the locality with which the former region is compared.

Concerning the list of lichens in Deane and Collins' "Flora of Middlesex Co., Mass.," in which Boston is located, little need be written. Though the lichen-flora treated in that list is much richer than that of either Chicago or Minneapolis, the number of species and varieties listed is only 146. After some experience in collecting about Boston, I know that this list for the large county of Middlesex is so incomplete that any conclusion as to the richness of the Minneapolis lichen-flora drawn from a comparison with this list would not be at all trustworthy, especially after making allowance for the much larger area covered by the latter list.

Also, from scattered statements in this paper, the inference might be drawn that I should have given more prominence to difference of substrata in accounting for the difference in number of lichens in the localities compared. Minneapolis gains 6 species on the Saint Peter sandstone, which is not found at Fayette, and lacks 6 species, occurring at Fayette, because the calcareous rocks seldom outcrop at the surface, and 5 species because of scarcity of calcareous earth. Possibly some allowance should be made for a probable slight advantage for Fayette in number of granitic rocks, though Minneapolis has the advantage in the per cent of species on these rocks. Of the 5 species gain for Fayette in the figures given above, 3 or 4, about 75 per cent, could be expected to occur at Minneapolis if the substrata were present. We could add as many more species for the possible advantage of Fayette in granitic rocks as substrata and still only have a total difference of 7 species resulting from difference in substrata. This would reduce the advantage of Fayette to be accounted for by difference in atmospheric conditions to 37 species, or 24 per cent. Subtracting this from the total difference of 28 per cent, leaves a doubtful 4 per cent to be accounted for by lack of substrata at Minneapolis.

It may also be thought that I have not taken into account the usual decrease in number of species in passing from warmer to colder regions. The distance of about 150 miles from south to north between the two localities compared is so small that little difference in number of species could result, the difference in mean annual temperature being between 2° F. and 3° F. The smaller number of individuals at Minneapolis also tends to prove that the difference in latitude has not helped to produce the difference in number of species, as the decrease in number of species, caused by colder climate, usually gives place to an increase in number of individuals. If the difference in lichen-floras were due to the above cause, northern species should come in, to some extent, at Minneapolis, to take the place of those found at Fayette, and not at the former place. *Parmelia olivacea* (L.) ACH., *Evernia prunastri* (L.) ACH., *Cetraria ciliaris* (ACH.) TUCK., and possibly *Alectoria jubata* (L.) TUCK var. *chalybeiformis* ACH. are more numerous, and occur on more substrata at Minneapolis as a result of more northern location, but not a species has come in.

So far as moisture influences distribution of lichens, the region along the Mississippi river should increase in richness of species as we pass south in the state from Minneapolis. Yet

so many factors influence distribution of species that one cannot predict with certainty the conditions in an unexplored region, even when adjacent to one already well studied. Further, the inference must not be hastily drawn that Minnesota as a state is comparatively poor in lichen-species, for, while no one locality may finally yield so large a number of species as Fayette, Iowa, with 220 already collected, yet within the borders of the former state are included some areas which are veritable gardens for certain species. As examples may be mentioned the *Cladonias* and *Umbilicarias* of the Lake of the Woods, listed in the first paper of this series, and the rock lichens of Taylors Falls already collected.

The list of species to follow certainly contains all or nearly all the species and varieties of lichens commonly occurring about Minneapolis, as well as a large portion of rare ones. It represents the lichen-flora of the area considered fairly well, so that notes and comparisons on distribution may be safely drawn from the list and observations made while collecting the plants. However, a continued search should in time add 30 or perhaps 40 species to the number here given for this area.

It is worth while to note the difference in precipitation of moisture for the two localities compared. This may be done by a consideration of the following table, which gives the yearly precipitation for St. Paul, Dubuque and Fayette, since reliable records have been kept at these places.

TABLE OF PRECIPITATION.

YEAR.	ST. PAUL.	DUBUQUE.	FAYETTE.
1874	35.50 inches.	30.76 inches.	....
1875	30.66 "	35.11 "	....
1876	23.42 "	50.28 "	....
1877	28.80 "	38.97 "	....
1878	22.78 "	38.26 "	....
1879	32.39 "	32.40 "	....
1880	29.76 "	40.32 "	....
1881	39.06 "	55.10 "	....
1882	23.14 "	32.84 "	....
1883	26.76 "	39.57 "	....
1884	26.11 "	42.86 "	....
1885	25.33 "	40.45 "	....
1886	22.89 "	27.51 "	....
1887	25.85 "	34.40 "	....
1888	25.86 "	33.31 "	....
1889	16.96 "	24.25 "	26.37 inches.
1890	23.38 "	43.16 "	46.74 "
1891	21.79 "	27.55 "	32.64 "
1892	32.55 "	48.47 "	40.34 "
1893	25.95 "	30.77 "	29.41 "
1894	25.80 "	19.35 "	21.64 "
1895	24.26 "	19.79 "	27.97 "
1896	34.73 "	42.29 "	34.49 "
Average 23 years	27.12 "	36.43 "	....
Average last 8 years	25.68 "	31.95 "	32.45 "

A comparison of the figures for St. Paul and Fayette for the eight years since the record has been kept for the latter place, shows a difference in annual precipitation of 6.77 inches in favor of Fayette. Comparison of St. Paul and Dubuque for the whole twenty-three years shows a difference of 9.31 inches per annum in favor of Dubuque. Now, comparison of Fayette and Dubuque for the eight years shows a difference of .50 inches per annum in favor of Fayette. Thus these last two places, only about fifty-five miles apart, show so little difference in amount of precipitation that the Dubuque figures may be substituted for Fayette without great error. Also, a glance at the table shows that St. Paul suffered less from the drouth of recent years than Dubuque, and hence than Fayette, so that the figures for the smaller number of years cannot be relied on, and 9.31 inches per annum doubtless is nearer the average difference between Minneapolis and Fayette in precipitation than is 6.77 inches. The use of St. Paul figures for Minneapolis can, of course, give rise to no appreciable error, and this difference of abuut 9.31 inches, with the accompanying difference of humidity of the atmosphere, seems to account very largely for the difference of 28 per cent in number of species of lichens. No reliable figures as to relative or absolute humidity could be obtained.

Though dealing with a small area, it will be seen that this paper may be regarded as preliminary to a study of the distribution of lichens all along the upper Mississippi river. Some of the questions that would arise in such a study have been briefly stated in this paper, and others have been suggested to me which I have not stated.

The principal conclusions as to distribution and habitat of the lichens about Minneapolis may be given as follows:

(1) The lichen-flora of Minneapolis and vicinity is not a rich one, being about 25 per cent poorer than some portions of northern Iowa, and doubtless also than southeastern Minnesota.

(2) The difference in number of lichens for the two areas compared affects species, but scarcely extends to genera to any appreciable extent. It also affects individuals, giving a large number of rare or infrequent species for Minneapolis.

(3) The cause of the comparatively smaller number of species and individuals for Minneapolis and vicinity is its dryer climate. Other causes act, as stated elsewhere, to a very mited extent.

(4) Proofs that the principal cause is dryer climate are as follows:
   (*a*) The lichens about Minneapolis are more inclined to confine themselves to moist places in denser woods, or about bodies of water
   (*b*) The gelatinous lichens, which thrive best in moist places, are rare about Minneapolis.
   (*c*) The genus *Peltigera*, whose species grow on the ground, where moisture is plentiful, is the best represented genus at Minneapolis when we take into account both species and individuals.
   (*d*) Were it not for other than atmospheric conditions the number of species of rock and earth lichens would be somewhat large when compared with those on trees.
   (*e*) Even the Saint Peter sandstone, usually occurring in moist places, bears fewer species of lichens about Minneapolis than in a region near McGregor, in northeastern Iowa.

(5) The most interesting portion of the lichen-flora of the region is that of the Saint Peter sandstone, which has yielded the characteristic species given in the fourth table.

(6) The tamarack swamps furnish floral elements somewhat distinct from those of other portions of the area studied.

(7) It seems that there is somewhat of a reduction of the number of habitats of certain species as compared with the other region better adapted to the development of lichens. This has been noted for *Usnea barbata* (L.) FR. var. *hirta* FR., and a comparison of the number of species of lichens found both on wood and rocks at Minneapolis and Fayette, as shown in the second table, is further evidence. Other instances could be drawn from a comparison of the lists for the two places. Yet, for the species *Parmelia olivacea* (L.) ACH., *Evernia prunastri* (L.) ACH. and *Cetraria ciliaris* (ACH.) TUCK., the number of habitats is larger than for northern Iowa. These are species that occur abundantly to the north of the United States, and the region about Minneapolis is better adapted to their development than the one with which it is compared.

(8) The scarcity of *Cladonias*, as regards individuals and earth growing species, I have not yet attempted to explain. If general scarcity is due to dry climate, one would suppose that the earth forms should predominate. Yet, I suspect that the old stumps and the Saint Peter sandstone furnish more moisture than does the earth, so that two-thirds of the species are confined to the first two substrata on this account. If so, the cause of scarcity, even of earth forms, may, after all, be dry climate.

LIST OF SPECIES AND VARIETIES.

1. **Ramalina calicaris** (L.) Fr. var. **fraxinea** Fr.

On trees, infrequent. July 4, 1896, no. 89.

Not previously reported from Minnesota.

2. **Ramalina calicaris** (L.) Fr. var. **fastigiata** Fr.

On trees, frequent. July 4, 1896, no. 89a.

3. **Ramalina calicaris** (L.) Fr. var. **farinacea** Schaer.

On Saint Peter sandstone, common. July 11, 1896, no. 170.

Not previously reported from Minnesota.

4. **Cetraria ciliaris** (Ach.) Tuck.

On tamaracks, old fences and Saint Peter sandstone, frequent. June 19, 1896, no. 96; July 10, 1896, no. 158.

Not previously reported from Minnesota.

5. **Evernia prunastri** (L.) Ach.

On tamaracks, old fences and Saint Peter sandstone, frequent. June 19, 1896, no. 19.

Rare further south, the only other state from which it is reported in the Mississippi valley being Iowa, where the writer has collected it twice.

6. **Usnea barbata** (L.) Fr. var. **florida** Fr.

On trees, rare. July 4, 1896, no. 92.

7. **Usnea barbata** (L.) Fr. var. **hirta** Fr.

On Saint Peter sandstone, rare. July 4, 1896, no. 92a; July 11, 1896, no. 169.

Passes into the next.

8. **Usnea barbata** (L.) Fr. var. **rubiginea** Michx.

On Saint Peter sandstone, common. July 11, 1896, no. 169a.

Not previously reported from Minnesota.

9. **Usnea angulata** Ach.

On tamarack, very rare. June 19, 1896, no. 21.

Not previously reported from Minnesota.

10. **Alectoria jubata** (L.) TUCK. var. **chalybeiformis** ACH.
On old fences, frequent. July 10, 1896, no. 218.
Not previously reported from Minnesota.

11. **Theloschistes chrysopthalmus** (L.) NORM.
On tamaracks, very rare. June 19, 1896, no. 20.

12. **Theloschistes polycarpus** (EHRH.) TUCK.
On dead wood and occasionally on living trees. Preferring Populus, frequent. July 4, 1896, no. 108; July 9, 1896, no. 129.

13. **Theloschistes lychneus** (DYL.) TUCK.
On trees, infrequent and seldom fruited. June 26, 1896, no. 32.

14. **Theloschistes concolor** (DICKS.) TUCK.
On trees, common. June 28, 1896, no. 29.

15. **Parmelia crinita** ACH.
On trees, infrequent. July 4, 1896, no. 102; July 13, 1896, no. 202.
Not previously reported from Minnesota.

16. **Parmelia tiliacea** (HOFFM.) FLOERK.
On trees, common. July 4, 1896, no. 93.

17. **Parmelia borreri** TURN.
On trees, common. June 24, 1896, no. 4.

18. **Parmelia borreri** TURN. var. **hypomela** TUCK.
On trees, rare. July 4, 1896, no. 74.
Sterile, hence not quite certain.
Not previously reported from Minnesota.

19. **Parmelia saxatilis** (L.) FR.
On trees, frequent. July 4, 1896, no. 79.

20. **Parmelia olivacea** (L.) ACH.
On trees, especially tamarack, also on old fences and Saint Peter sandstone, frequent. June 19, 1896, no. 17; July 9, 1896, no. 131.

21. **Parmelia caperata** (L.) ACH.
On trees, common. June 28, 1896, no. 47.

22. **Parmelia conspersa** (EHRH.) ACH.
On granite and Saint Peter sandstone, rare and sterile. July 3, 1896, no. 77; July 13, 1896, no. 115.

23. **Physcia speciosa** (WULF., ACH.) NYL.
At base of trees, rather rare. July 4, 1896, no. 85.

24. **Physcia hypoleuca** (MUHL.) TUCK.
On trees, rare. July 4, 1896, no. 86.

25. **Physcia granulifera** (ACH.) TUCK.
On trees, frequent. July 4, 1896, no. 95.
Not previously reported from Minnesota.

26. **Physcia pulverulenta** (SCHREB.) NYL.
On wood, frequent. July 4, 1896, no. 81a.

27. **Physcia stellaris** (L.) TUCK.
On trees, abundant. June 25, 1896, no. 23.

28. **Physcia stellaris** (L.) TUCK. var. **apiola** NYL.
On granitic rocks, rare. July 9, 1896, no. 134.
Not previously reported from Minnesota.

29. **Physcia tribacia** (ACH.) TUCK.
On trees near the base, infrequent. June 28, 1896, no. 41.

30. **Physcia cæsia** (HOFFM.) NYL.
On granitic rocks, infrequent. July 3, 1896, no. 72.

31. **Physcia obscura** (EHRH.) NYL.
On trees, frequent. July 4, 1896, no. 75.

32. **Physcia adglutinata** (FLOERK.) NYL.
On trees, frequent. July 4, 1896, no. 90.

33. **Peltigera polydactyla** (NECK.) HOFFM.
On earth, rare. Aug. 16, 1896, no. 226.

34. **Peltigera pulverulenta** (TAYL.) NYL.
On earth, infrequent. June 30, 1896, no. 39.
Not previously reported from Minnesota.

35. **Peltigera rufescens** (NECK.) HOFFM.
On earth, infrequent. June 30, 1896, no. 40.
Not previously reported from Minnesota.

36. **Peltigera canina** (L.) HOFFM.
On earth, very common. June 30, 1896, no. 44.

37. **Peltigera canina** (L.) HOFFM. var. **spuria** ACH.
On earth, frequent. July 9, 1896, no. 124.

38. **Peltigera canina** (L.) HOFFM. var. **sorediata** SCHÆR.
On earth and Saint Peter sandstone, frequent. July 9, 1896, no. 142; July 14, 1896, no. 165.

See note under no. 28 of first paper of this series.

But the plant from the sandstone shows scarcely fibrillose forms like var. *spuria* ACH. except for the soredia.

39. **Pannaria languinosa** (ACH.) KŒRB.

On shaded rocks and mosses, common. June 30, 1896, no. 51; July 11, 1896, no. 157.

The pale sulphur-colored form common in Europe, but not before reported for the American lichen, occurs on the Saint Peter sandstone. It has also been collected by the writer on the same rock formation in Iowa.

Not previously reported from Minnesota.

40. **Pannaria nigra** (HUDS.) NYL.

On calcareous rocks, rare. July 13, 1896, no. 138.

Not previously reported from Minnesota.

41. **Omphalaria** sp.

On calcareous rocks, rare. July 30, 1896, no. 196. Thallus of small black fronds, rounded above, and the larger ones becoming somewhat roughened and lobed. Apothecia innate and frequently several in a frond. Spores simple, colorless, $\frac{5\text{-}8}{3\text{-}4}$ mik, numerous in asci. Gonimia in clusters. Probably a new species.

42. **Collema flaccidum** ACH.

On trees, rare. June 19, 1896, no. 18.

Not previously reported from Minnesota.

43. **Collema pulposum** (BERNH.) NYL.

On clayey earth, infrequent. June 28, 1896, no. 28; June 25, 1896, no. 14; July 20, 1896, no. 179.

Not previously reported from Minnesota.

44. **Leptogium lacerum** (SW.) FR.

On calcareous rocks among mosses, rare. July 20, 1896, no. 139.

Not previously reported from Minnesota.

45. **Placodium elegans** (LINK.) DC.

On calcareous rocks, rare. July 31 1896, no. 225.

46. **Placodium cinnabarinum** (ACH.) ANZ.

On granitic and calcareous rocks, rare. July 3, 1896, no. 69; July 10, 1896, no. 109.

Not previously reported from Minnesota.

47. **Placodium microphyllinum** TUCK.

On dead wood, rare. July 11, 1896, no. 182a.

Not previously reported from Minnesota.

48. **Placodium citrinum** (HOFFM.) LEIGHT.

On calcareous rocks, probably rare. July 11, 1896, no. 150a; July 30, 1896, no. 204.

Not previously reported from Minnesota.

49. **Placodium aurantiacum** (LIGHT.) NAEG. and HEPP.

On trees and calcareous rocks, frequent. June 26, 1896, no. 30; July 2, 1896, no. 52.

50. **Placodium cerinum** (HEDW.) NAEG. and HEPP.

On trees, abundant. July 12, 1896, no. 193.

The usual form occurs, and also another with whitish thalline exciple and sub-pruinose apothecia. The last, usually on *Ulmus*, is, I think, worthy of a distinct name, though thus far always included with this species.

51. **Placodium cerinum** (HEDW.) NAEG. and HEPP. var. **pyracea** NYL.

On dead wood, frequent. July 12, 1896, no. 193a.

Not previously reported from Minnesota.

52. **Placodium cerinum** (HEDW.) NAEG. and HEPP. var. **sideritis** TUCK.

On granitic rocks, frequent. June 26, 1896, no 11.

Not previously reported from Minnesota.

53. **Placodium vitellinum** (EHRH.) NAEG. and HEPP.

On wood, infrequent. July 10, 1896, no. 147.

Spores nearly all simple, scarcely exceeding 8 in asci.

54. **Placodium vitellinum** (EHRH.) NAEG. and HEPP. var **aurellum** ACH.

On calcareous and granitic rocks, frequent. June 28, 1896, no. 54; July 3, 1896, no. 73.

Spores 8 in asci, and always 2-celled in the specimens on calcareous rocks. On granitic rocks spores are 8 in asci, but frequently simple.

Not previously reported from Minnesota.

55. **Lecanora rubina** (VILL.) ACH.

On granitic rocks, rare. July 13, 1896, no. 206

56. **Lecanora muralis** (SCHREB.) SCHÆR. var. **saxicola** SCHÆR.

On granitic rocks, rare. June 24, 1896, no. 1.

Not previously reported from Minnesota.

57. **Lecanora subfusca** (L.) ACH.

On trees, infrequent. July 4, 1896, no. 94.

A common lichen in northern Iowa, but about Minneapolis it is confined to damp woods—a result of dryer climate.

58. **Lecanora subfusca** (L.) ACH. var. **argentata** ACH.
On trees, rare. July 9, 1896, no 112.
Not previously reported from Minnesota.

59. **Lecanora subfusca** (L.) ACH. var. **coilocarpa** ACH.
Rarely found on red cedar, but more frequently on Saint Peter sandstone. July 11, 1896, no. 182a; July 30, 1896, no. 227.
The apothecia become large in some of the rock specimens.

60. **Lecanora hageni** ACH.
On calcareous rocks and old boards, common. June 24, 1896, no. 2; July 10, 1896, no. 147a.
Not previously reported from Minnesota.

61. **Lecanora varia** (EHRH.) NYL.
On dead wood and Saint Peter sandstone, frequent. July 4, 1896, no. 84; July 10, 1896, no. 132; July 18, 1896, no. 195.

62. **Lecanora varia** (EHRH.) NYL. var. **symmicta** ACH.
On old boards, rare. July 9, 1896, no. 123a.

63. **Lecanora erysibe** NYL.
On calcareous rocks, rare. July 20, 1896, no. 175.
Not previously reported from Minnesota.

64. **Lecanora cinerea** (L.) SOMMERF.
On granitic rocks, rare. July 9, 1896, no. 135.

65. **Lecanora cinerea** (L.) SOMMERF. var. **gibbosa** NYL.
On granitic rocks, rare. July 30, 1896, no. 198.

66. **Lecanora xanthophana** NYL.
On granitic rocks, very rare. July 18, 1896, no. 212.
Not previously reported from Minnesota.

67. **Lecanora cervina** (PERS.) NYL.
On granitic rocks, infrequent. July 18, 1896, no. 213.
Not previously reported from Minnesota.

68. **Lecanora privigna** (ACH.) NYL.
On calcareous rocks, rare. June 28, 1896, no. 36.
Not previously reported from Minnesota.

69. **Lecanora privigna** (ACH.) NYL. var. **pruinosa** AUCT.
On calcareous rocks, infrequent. July 2, 1896, no. 56; July 18, 1896, no. 209.
Not previously reported from Minnesota.

70. **Rinodina oreina** (ACH.) MASS.
On granitic rocks, rare. June 26, 1896, no. 27.
Not previously reported from Minnesota.

71. **Rinodina sophodes** (ACH.) NYL.

On old boards and granitic rocks, abundant. July 10, 1896, no. 151; July 10, 1896, no. 144; July 3, 1896, no. 81; July 16, 1896, no. 188a.

72. **Rinodina sophodes** (ACH.) NYL. var **exigua** FR.

On trees, where the thalline exciple is usually present, but the spores frequently reach 30 in each ascus. Also on dead wood, where it is more typical externally, but the spores only 10 or 12 in each ascus. Probably infrequent. July 9, 1896, no. 123; July 9, 1896, no. 145.

Not previously reported from Minnesota.

73. **Pertusaria velata** (TURN.) NYL.

On trees, rare, A single specimen was collected and lost.

74. **Pertusaria communis** DC.

On trees, rare. July 11, 1896, no. 163b.

Not previously reported from Minnesota.

75. **Pertusaria pustulata** (ACH.) NYL.

On trees, infrequent. July 4, 1896, no. 96; July 18, 1896, no. 189.

Not previously reported from Minnesota.

76. **Urceolaria scruposa** (L.) NYL.

On Saint Peter sandstone, common. July 11, 1896, no. 154.

Not previously reported from Minnesota.

77. **Cladonia mitrula** TUCK.

On earth, frequent. June 30, 1896, no. 37.

78. **Cladonia cariosa** (ACH.) SPRENG.

On earth at base of stumps, rare. July 31, 1896, no. 230.

79. **Cladonia pyxidata** (L.) FR.

On earth, common. June 28, 1896, no. 33.

80. **Cladonia fimbriata** (L.) FR. var. **tubæformis** FR.

On earth and old logs, frequent. June 28, 1896, no. 38.

81. **Cladonia gracilis** (L.) NYL.

On old stumps, rare. July 31, 1896, no. 228.

82. **Cladonia gracilis** (L.) NYL. var. **verticellata** FR.

On old stumps, rare. July 31, 1896, no. 205.

83. **Cladonia cæspiticia** (PERS.) FL.

On Saint Peter sandstone, frequent. July 11, 1896, no. 156.

Not previously reported from Minnesota.

84. **Cladonia cornucopioides** (L.) Fr.
On Saint Peter sandstone, rare. July 14, 1896, no. 220.
Not previously reported from Minnesota.

85. **Cladonia cristatella** Tuck.
On old stumps, infrequent. July 31, 1896, no. 229.

86. **Biatora hypnophila** (Turn.) Tuck.
On moss and earth, infrequent. June 30, 1896, no 45; July 10, 1896, no. 159.
Not previously reported from Minnesota.

87. **Biatora rubella** (Ehrh.) Rabenh.
On trees, common. July 4, 1896, nos. 88, 101 and 107.

88. **Biatora fusco-rubella** (Hoffm.) Tuck.
On trees, rare. July 20, 1896, no. 194; July 11, 1896, no. 153.
Not previously reported from Minnesota.

89. **Biatora inundata** Fr.
On wet rocks, abundant. July 2, 1896, no. 62; July 8, 1896, no. 117; July 9, 1896, no. 126.
Not previously reported from Minnesota.

90. **Biatora muscorum** (Sw.) Tuck.
On earth and Saint Peter sandstone, frequent. July 11, 1896, no. 164; July 20, 1896, no. 207.
Not previously reported from Minnesota.

91. **Biatora umbrina** (Ach.) Tuck.
On calcareous rocks, probably rare. June 28, 1896, no. 34.
Spores hamate, broadly u-shaped, slightly s-shaped or little curved.
Not previously reported from Minnesota.

92. **Lecidea enteroleuca** Fr.
On trees and dead wood, infrequent. July 4, 1896, no 80b; July 11, 1896, no. 182.

93. **Buellia parasema** (Ach.) Th. Fr.
On trees, infrequent. July 4, 1896, no. 104.

94. **Buellia myriocarpa** (DC.) Mudd.
On dead wood, infrequent. July 30, 1896, no. 192.
Not previously reported from Minnesota.

95. **Buellia myriocarpa** (DC.) Mudd. var. **polyspora** Willey.
On trees, rare. July 4, 1896, no. 116.
Not previously reported from Minnesota.

96. **Opegrapha varia** (PERS.) FR.
On trees, frequent. July 4, 1896, no. 107a; July 9, 1896, no. 120.
Not previously reported from Minnesota.

97. **Graphis scripta** (L.) ACH.
On trees, common. June 28, 1896, no. 50; July 2, 1896, no. 61; July 11, 1896, no. 163.

98. **Arthonia lecideella** NYL.
On trees, frequent. July 7, 1896, no. 137.
Not previously reported from Minnesota.

99. **Arthonia radiata** (PERS.) TH. FR.
On trees, rare. July 2, 1896, no. 66; July 4, 1896, no. 105; July 11, 1896, no. 168.
Not previously reported from Minnesota.

100. **Arthonia punctiformis** ACH.
On trees, infrequent. July 7, 1896, no. 113.
Not previously reported from Minnesota.

101. **Acolium tigillare** (ACH.) DC.
On old fences, infrequent. July 7, 1896, no. 114.

102. **Endocarpon miniatum** (L.) SCHÆR.
On calcareous rocks, infrequent. July 31, 1896, no. 203.
Not previously reported from Minnesota.

103. **Endocarpon miniatum** (L.) SCHÆR. var. **complicatum** SCHÆR.
On calcareous and granitic rocks, rare. July 14, 1896, no. 160; July 14, 1896, no. 161.
Not previously reported from Minnesota.

104. **Endocarpon hepaticum** ACH.
On calcareous earth, rare. Specimen lost.
Not previously reported from Minnesota.

105. **Endocarpon pusillum** HEDW.
On calcareous rocks, abundant. June 24, 1896, no. 5; June 25, 1896, no. 9.
Not previously reported from Minnesota.

106. **Endocarpon pusillum** HEDW. var. **garovaglii** KPH.
On calcareous rocks and Saint Peter sandstone, rare. July 18, 1896, no. 215; July 30, 1896, no. 216.
Not previously reported from Minnesota.

107. **Verrucaria nigrescens** PERS.

On calcareous and granitic rocks, common. June 25, 1896, no. 25; June 28, 1896, no. 42; July 2, 1896, no. 67.

Not previously reported from Minnesota.

108. **Verrucaria fuscella** FR.

On calcareous rocks, rare. July 8, 1896, no. 124; July 18, 1896, no. 184.

Not previously reported from Minnesota.

109. **Verrucaria muralis** ACH.

On calcareous rocks, rare. June 28, 1896, no. 36; July 9, 1896, no. 125.

Not previously reported from Minnesota.

110. **Pyrenula punctiformis** (ACH.) NÆG.

On trees, infrequent. June 17, 1896, no. 35; July 16, 1896, no. 188.

Two forms are placed here, one having 2-celled spores and the other 4-celled ones. Doubtless one will eventually be placed elsewhere.

Not previously reported from Minnesota.

111. **Pyrenula leucoplaca** (WALLR.) KBR.

On trees, probably rare. July 4, 1896, no. 87; July 11, 1896, no. 153a.

Not previously reported from Minnesota.

112 **Pyrenula nitida** ACH.

On trees, infrequent. July 4, 1896, no. 99.

Not previously reported from Minnesota.

113 **Pyrenula thelena** ACH.

On *Betula*, rare. July 4, 1896, no. 97.

Not previously reported from Minnesota.

XLIV. A RE-ARRANGEMENT OF THE NORTH AMERICAN HYPHOMYCETES.
II.—(*Concluded.*)

ROSCOE POUND and FREDERIC E. CLEMENTS.

Dendryphium WALLR., which was omitted in Part I, has been divided. The catenulate-spored section of which *D. comosum* WALLR. is the type has been referred to *Schizocephalum* PREUSS (Minn. Bot. Stud. **9**: 666. 1896). *Dendryphium* WALLR. has been retained for the section *Brachycladium*, of which *Dendryphium nodulosum* SACC. is the type. Thus constituted, it is one of the *Diplosporiaeae* (l. c. 659).

51. **DENDRYPHIUM** WALLR. Fl. Crypt. Germ. **2**: 300. 1833.

Vegetative hyphae obsolete; sporophores erect, or ascending, septate, swollen at the septa, the stout branches arising pseudo-acrogenously from the swellings, fuscous; conidia rarely or not at all catenulate, acrogenous, solitary, or 2—3-clustered, oblong to fusoid-cylindrical, phragmosporous, fuscous.

Family **STILBACEAE** FR. Syst. Myc. Introd. **1**: 47. 1821.

Sterile hyphae obsolescent; fertile hyphae collected into a dense, stipitoid stroma, hyaline or fuscous; conidiophores either terminal, or lateral, forming a capitulum; spores globose to cylindrical, amero-dictyosporous, hyaline or fuscous.

Subfamily **Schaerocybeae.**

Conidiophores terminal, i. e., apices of the fertile hyphae; capitulum more or less globose, or turbiniform generally distinct from the stipe.

Tribe **Stilbeae** FR. Summa Veg. Scand. **2**: 468. 1849.

Conidiophores simple, or sparingly branched; conidia solitary.

Subtribe **Hyalostilbeae** SACC. Mich. **2**: 32. 1882.

Stroma hyaline, or bright-colored.

1. **STILBUM** Tode. Fung. Meckl. **1**: 10. 1790.

Stipe erect, cylindrical, the fertile apices of the hyphae collected into a dense globose, or capitate capitulum; hyaline, strict, but not rigid; conidia simple, hyaline, globose to ellipsoid.

The number of species reported for the United States is 29.

2. **ACTINICEPS** B. & Br. Journ. Linn. Soc. **15**: 85. *Pl. 2. f. 3.* 1877.

Stipe as in *Stilbum*, but the capitulum composed of two sorts of hyphae, the sterile terminating in stiff projecting, radiating spicules, the fertile thin, branching, bearing the small globose, or ellipsoid conidia.

A small genus of but two species, one of which occurs in this country.

3. **MARTINDALIA** Sacc. & Ell. Miss. Myc. **2**: 16. 1884.

Stipe stilboid; capitulum composed of elongated spiral, nodulose sporophores; conidia globose, hyaline.

Contains but a single species, reported for this country.

4. **CILICIOPODIUM** Corda. Sturm. DC. Fl. III. **12**: 75.

Stipe erect, or ascending, composed of simple, or branched filaments, clavate-cylindrical, bright-colored; capitulum obsolescent; conidia acrogenous, hyaline, globose, or ellipsoid.

Two species of this genus are reported for the United States.

5. **ATRACTIUM** Link. Berl. Mag. **3**: 10. 1809.

Stipe cylindrical, erect, capitate; sporophores erect, typically single, parallel; capitulum obsolescent; conidia falcate, hyaline, 2-pluriseptate.

This genus contains but a single American representative.

Subtribe **Sporocybeae** Fr. Summa Veg. Scand. **2**: 467. 1849.

Stroma fuscous, or dark-colored.

6. **SPOROCYBE** Fr. Syst. Orb. Veg. **1**: 170. 1825.

Stipe composed of rigid, erect, fuscous hyphae capitate above; capitulum globose to turbiniform; conidia simple, fuscous, globose, or ellipsoid.

Represented in the United States by 17 species.

7. **GRAPHIUM** Corda. Icon. Fung. **1**: 18. 1837.

Stipe erect, rigid, cylindrical, capitate, or clavate above, fuscous; apices of the hyphae sporiferous, diverging; conidia simple, hyaline, ovoid or ellipsoid.

Fifteen species occur in the United States. *Graphium* is intermediate between *Stilbum* and *Sporocybe*.

8. **ARTHROBOTRYUM** Ces. Berk. Outl. Brit. Fung. 342. 1860.

Arthrosporium Sacc. Mich. **2**: 32. 1880.
Didymobotryum Sacc. Syll. Fung. **4**: 626. 1886.

Stipe compact, erect, rigid, capitate above, pallid or fuscous; conidia oblong, 2-pluriseptate, fuscous or hyaline.

As here limited, *Arthrobotryum* contains 6 species reported for this country.

Arthrobotryum compositum (Ell.)
Arthrosporium compositum Ell. Bull. Torr. Bot. Club. **8**: 64. 1881.

Arthrobotryum didymum (Cooke.)
Stilbum didymum Cooke. Grev. **7**: 34. 1878.
Didymobotryum cookei Sacc. Syll. Fung. **4**: 626. 1886.

Arthrobotryum pubescens (C. & E.)
Graphium pubescens C. & E. Grev. **6**: 5. 1877.
Didymobotryum pubescens (C. & E.) Sacc. Syll. Fung. **4**: 627. 1886.

9. **ISARIOPSIS** Fres. Beitr. Myk. 87. 1863.

Stilbomyces E. & E. Proc. Acad. Nat. Sci. Phil. **1895**: 441. 1895.

Hyphae erect, loose, cylindrical, scarcely or not at all capitate, fuscous, or pallid; conidia oblong, linear or cylindrical, fuscous or hyaline.

Represented by 7 species in the United States.

Tribe **Coremieae.**

Stipe and capitulum as in *Stilbeae*, but the sporophore typically verticillate-ramose, and the conidia catenulate.

10. **COREMIUM** Lk. Obs. Myc. **1**: 19. 1809.

Stysanus Corda. Icon. Fung. **1**: 21. 1837.

Stipe erect, cylindrical, broadly capitate, or clavate above, fuscous, or bright colored; conidia simple, *i. e.* non-septate, ovoid to fusoid, fuscous, or bright colored.

This genus has 9 representatives in this country.

Coremium berkeleyi (Mont.)
Graphium berkeleyi Mont. Pl. Cell. Nouv. **8**: 303. 1838.
Stysanus berkeleyi (Mont.) Sacc. Syll. Fung. **4**: 623. 1886.

COREMIUM BICOLOR (WEB.)
Embolus bicolor WEB. Prim. Flor. Hols. 1780.
Isaria stemonitis PERS. Com. Fung. Clav. 111. 1797.
Cephalotrichum stemonitis (PERS.) Nees. Syst. 87. 1816.
Stysanus stemonitis (PERS.) Corda Icon. Fung. **1**: 112. *Pl. 4. f. 283.* 1837.

COREMIUM MONILIOIDES (A. & S.)
Isaria monilioides A. & S. Consp. Fung. Lusat. 362. *Pl. 12. f. 8.* 1805.
Cephalotrichum monilioides LK. Sp. Pl. **2**: 112. 1825.
Stysanus monilioides (A. & S.) Corda Icon. Fung. **2**: 17. *Pl. 11. f. 72.* 1838.

11. **TRICHURUS** CLEMENTS & SHEAR. Rep. Bot. Surv. Nebr. **4**: 7. 1896.

Stipe and sporophore as in *Coremium*, but the capitulum densely beset with long, strict spines.

Contains but a single species, found in this country.

12. **GRAPHIOTHECIUM** FUCKEL. Symb. Myc. 366. 1869.

Stipe erect, cylindrical, capitate clavate above, perithecioid at the base; hyphae parallel, fasciculate; conidia simple, hyaline, ovoid.

Represented in the United States by two species only.

13. **HEYDENIA** FRES. Beitr. Myk. 47. 1852.

Stipe elongate-cylindrical, rigid, fuscous, pseudoprosenchymatous in texture, dilated above into an irregular disk, from which arises the subglobose capitulum; sporophores nonramose, septate; conidia globose, pleurogenous.

Represented in this country by a single species.

Subfamily **Isarieae** BROGN. Essai Champ. 1825.

Conidiophores lateral, i. e., short branches, or sterigmata borne laterally upon the stroma, in some cases apices of the fertile hyphae, but then emerging all along the stroma; capitulum linear, cylindrical, or clavate, scarcely distinct from the stipe.

14. **ISARIA** PERS. Tent. Disp. Meth. 41. 1797.

Stipe erect, rarely branched, everywhere sporophorous above, sterigmata usually formed by the tips of the fertile hyphae; capitulum indefinite, or lacking; conidia globose, or ellipsoid, simple, hyaline.

Thirty-one species, mostly conidial stages of Cordyceps, occur in the United States.

15. **PODOSPORIUM** Schw. Syn. Amer. Bor. 278. 1834.

Podosporella E. & E. Proc. Acad. Nat. Sci. Phil. **1894**:385. 1894.

Stipe erect, strict, black, composed of densely congested, carbonaceous, rarely soft, hyphae, cylindrical or linear-subulate; sporophores short, lateral, typically simple; conidia scattered, septate, fuscous, cylindrical, or clavate cylindrical.

Podosporium crucigerae (Schw.)
Dematium crucigerae Schw. Syn. Car. 128. 1822.
Podosporium rigidum Schw. Syn. Amer. Bor. 278. *Pl. 19. f. 1.* 1834.

Podosporium humile (E. & E.
Podosporella humilis E. & E. Proc. Acad. Nat. Sci. Phil. **1894**: 385. 1894.

Family **TUBERCULARIACEAE** (Ehrenb.)

Tuberculariei Ehrenb. Sylv. Myc. Berl. 12. 1818.

Sporophores collected in a waxy or gelatinous, wart-like head or tuft (*sporodochium*).

Although they grade into the *Stilbaceae* to some extent, the *Tuberculariaceae* are well distinguished as a group of the *Hyphomycetes.* On the other hand, the black or dark-colored genera approach so closely to the *Melanconieae* that many of them are not to be placed with certainty in either group. Several genera have been placed at various times first in one and then in the other by the same author. Thus *Epiclinium* was first put in the *Melanconieae* as a sub-group of *Didymosporium* by Saccardo, who later separated it from *Didymosporium* and placed it in his *Tubercularieae.* Some of these genera also approach genera placed in the *Sphaeropsideae,* especially in *Nectrioideae* and *Excipulaceae.* Sometimes the ambiguity extends only to a few species in a genus, as in *Trimmatostroma,* in which certain species are clearly of the Melanconieous type, while our *T. americana* is rather of the Tuberculariaceous type. Among the *Sphaeropsideae, Cyphina* and *Patellina* in the *Nectrioideae, Dinemasporium* and *Amerosporium* in the *Excipulaceae,* and some species of *Leptothyrium* in the *Leptostromaceae* might well be placed with some *Melanconieae* and with some *Tuberculariaceae.* Compare with these genera some *Volutelleae.* Saccardo has placed *Patellina* both in *Excipulaceae* and in *Tuberculariaceae,* adhering at length to the latter view. It is apparent, then, that it is largely a matter of personal taste where such groups are placed.

Schrœter,* evidently with these difficulties in mind, separated

* Krypt. Flor. v. Schles. Pilz. 3^2: 8. 1893.

the *Tuberculariaceae* from the *Hyphomycetes*, making them coordinate with the latter group and the *Melanconieae*. But this does not relieve the difficulty of separating *Tuberculariaceae* from *Melanconieae* and both from some *Sphaeropsideae*. And the close relation of *Stilbum*, which needs only to shorten its stipe to become one of the *Knyarieae*, precludes drawing too great a line between *Stilbaceae* and *Tuberculariaceae*.

Significant also is the paralellism between some genera and genera clearly Melanconieous, as, for example, between *Sphaeridium* and *Trullula* and *Blennoria*.

Perhaps eventually portions of the *Tuberculariaceae*, some *Excipulaceae*, and some *Nectrioideae*, will have to be united with the *Melanconieae* to form a new group. But this will be far from satisfactory.

The *Tuberculariaceae* for the most part represent conidial forms of *Hypocreaceae*. *Trichoderma* in the *Mucedinaceae* is at once suggested by this fact as well as by its morphological similarity. *Fusisporium*, a sub-genus of *Fusarium*, might be placed as well in the *Trichodermeae*, and was long kept separate from *Fusarium*. But, under varying conditions, the same fungus has been found taking on the *Fusarium* form or the *Fusisporium* form, or both successively.

We have removed, not without doubt, *Patellina*, and have retained *Epicoccum*, *Epiclinium* and *Trimmatostroma*.

Tribe **Knyarieae** POUND & CLEMENTS.

Sporodochia not setose or ciliate, sporophores simple or branched, never verticillate, conidia single, that is, not catenulate.

1. **KNYARIA** O. KUNTZE. Rev. Gen. Pl. **2**:855. 1891.

Tubercularia TODE. Fung. Mecklenb. **1**:18. 1790, not *Tubercularia* WIGG. Prim. Fl. Holsat. 87. 1780.

Sporodochia wart-like, sessile or subsessile, waxy, usually reddish; conidia acrogenous or acro-pleurogenous, elliptical or oblong, continuous.

The sporodochium consists of a mass of simple or branched conidiophores arising from a pseudoparenchymatous layer, and expanded somewhat above. The conidia form a waxy layer covering the surface. The species are largely conidial forms of *Nectria*. Several of the remaining genera of this tribe might well be united with *Knyaria*, the principal distinction being in the shape of the sporodochia.

Eighteen species are reported from North America. The most common is:

KNYARIA PURPUREA (L.)
Tremella purpurea L. Spec. Pl. 1158. 1753.
Tubercularia vulgaris TODE. Fung. Mecklenb. **1**: 18. 1790.

The Linnaean description clearly indicates this species, even if Tode did not indirectly refer to the same species as a synonym.

Tuberculina SACC. containing a number of species parasitic in *Uredineae*, is now generally placed in the *Ustilagineae.* Some species, however, are of a different nature from the typical *Tuberculina*, and are perhaps no more than small *Knyarieæ*, e. g. *T. solanicola* E. & E. Journ. Myc. **7**: 278. 1893.

Granularia SACC. Mich. **2**:648. 1882. is of a doubtful position. The sporodochia (?) are globular, and composed of compacted, filiform, hyaline hyphae. The surface of the sporodochia is formed by the compact mass of hyphae, and the interior is composed of hyphae and ovoid spores borne acrogenously. A form of this character has no place in this group. On account of *Granularia* ROTH (1791), the name cannot well be retained.

Illosporium MART. Fl. Crypt. Erl. 325. 1817. Contains a number of forms growing on lichens, and some growing on wood, dead stems, and even leaves. After investigating some of the lichenicolous species pretty carefully, we are satisfied that they are to be placed in Dr. Thaxter's group of *Myxobacteriaceae*, if not in some cases identical with the forms he has discovered.(1) Several of the xylogenous species appear to be of the same nature. The phyllogenous forms seem to be of a different character, but we are not concerned with them here.

2. **AEGERITA** PERS. Tent. Disp. Meth. Fung. 40. 1797.

Sporodochia subglobose, sessile, superficial, subfarinaceous (on account of the conidia on the surface); conidiophores hyaline or light colored, pallid, short, rather thick, simple or slightly branched, sometimes obsolete; conidia rather large, globose or ovoid, acrogenous or sub-acrogenous, continuous.

Five species are reported from North America, of which some are rather doubtful.

(1) Compare also Zukal's *Myxobotrysaceae* (Bericht. Deutsch. Bot. Ges. **14**:340. 1896), which seems to be substantially the same group.

Sphaerosporium SCHW. Syn. Fung. Am. Bor. 303, is not very well characterized. It has plane, pulvinate sporodochia covered with a stratum of ochraceo-rufous, rather large, globose conidia. But one species is described.

Spacelia LEV. is composed of conidial stages of *Claviceps* and *Epichloe*, and the only species found in our limit are sufficiently known in their maturer stages.

3. **HYMENELLA** FR. Syst. Myc. **2**: 233. 1823.

Hymenula FR. Elench. Fung. **2**: 37. 1828.
Hymenopsis SACC. Syll. Fung. **4**: 744. 1886.

Sporodochia disciform, scutellate-disciform, or sub-convex, bright colored or black; conidiophores simple or subsimple; conidia ovoid or oblong, acrogenous, continuous.

Eleven species are reported from North America. The species placed in the section *Hymenobactron* under *Hymenopsis* by Saccardo, having bacillar conidia, may well be separated. But it does not seem necessary to retain *Hymenopsis*, which is based solely on the dark color of the conidiophores and conidia.

4. **THECOSPORA** HARKN. Bull. Cal Acad. Sci. **1**: 41. 1884

Sporodochia white or yellowish, globulose, indurate; conidiophores slender, sub simple or branched; conidia borne here and there on the conidiophores, involved in a hyaline mucous layer, continuous.

Two species are described.

5. **STIGMATELLA** B. & C. Grev. **3**: 97. 1875; Berk. Outl. Crypt. Bot. 313. 1857. (Figure and name only.)

Sphaerocrea SACC. & ELL. Mich. **2**: 582. 1882.

Sporodochia globose, composed of compacted, fasciculate, continuous simple or furcate conidiophores; conidia large, globose ellipsoid, continuous, adhering to the conidiophore by a more or less persistent projection.

Two species are described.

6. **EPIDOCHIUM** FR. Summ. Veg. Scand. 471. 1849.

Sporodochia waxy or gelatinous becoming fleshy, sub-globose or verruciform, or discoid, often tremelloid, black, olivaceous, or pallid; conidiophores filiform, equal, simple or branched; conidia oblong, ellipsoid, or sub-falcate, continuous.

Two species are desbribed from North America. In some of the European forms the conidiophores pass into globose or clavate "pseudospores." These forms have been placed by many among the *Tremellineae*, where, perhaps, some of the species put in *Epidochium* belong. The section *Hormodochium* SACC. has catenulate conidia and should be separated. None of the North American species are included in it.

7. **EPICOCCUM** LK. Obs. Myc. 2:32. 1813.

Sporodochia globose or convex, cellular; conidiophore, very short, dark colored; conidia subglobose, minutely verrucose, usually areolate.

The species occur on dead, decaying herbaceous stems and leaves, for the most part, where their presence is indicated by a red or purple discoloration.

Nine species are reported from North America.

8. **EPICLINIUM** FR. Summ. Veg. Scand. 475. 1849.

Sporodochia applanate, pezizoid or truncate, black; conidiophores reduced or obsolete; conidia oblong, one-septate, pedicellate (i. e., on reduced conidiophores), upon a corneous stroma.

The type is a Schweinitzian species described as a *Didymosporium.*

9. **BACTRIDIUM** KUNZE. Myk. Heft. 1:5. 1817.

Sporodochia rather thin, hemispherical, convex; conidiophores short, terete, simple or subsimple; conidia large, elongate oblong-cylindrical, many septate.

Three species are reported from North America.

10. **EXOSPORIUM** LK. Obs. Myc. 1:8. 1809.

Sporodochia convex, compact; conidiophores short, simple, densely fasciculate, black; conidia acrogenous, oblong or terete, many septate.

Three species are reported from North America.

Scoriomyces ELL. and SACC. Misc. Myc. 2:18. 1884. is of doubtful position. The sporodochium is composed of the apices of rhizomorpha-like fibres, and is waxy, and amorphous. The rhizomorpha-like fibers form within a thick net-work in each subhexagonal areola of which a spore is produced. No sporophores or hyphae have been observed. Such a form can hardly be placed in this group with propriety. Two species are described.

11. **SPEGAZZINIA** Sacc. Mich. 2: 37. 1880.

Sporodochia convex, rather dense, black; conidiophores subterete, fasciculate; conidia terminal, borne on sterigmata, sarciniform, usually cruciate four-celled.

One species is described for North America.

12. **DICRANIDION** Harkn. Bull. Cal. Acad. Sci. 1: 163 1885.

Sporodochia minute, pulvinate; conidiophores short, branching; conidia acrogenous, subterete, septate, bifurcate, of the shape of a tuning fork.

One species is described.

13. **EVERHARTIA** Sacc. & Ell. Mich. 2: 580. 1882

Sporodochia verruciform, fuscous; conidiophores septate, subdichotomous or obsolete; conidia densely conglobate, or enclosed in a viscous mass, at first involved in mucus, cylindrical, many septate, once to several times spirally coiled, hyaline.

Two species are described. In one species the conidiophores are interwoven with sterile hyphae.

14. **TROPOSPORIUM** Harkn. Bull. Cal. Acad. Sci. 1: 34. 1884.

Sporodochia applanate, farinaceous; conidiophores elongate, loose, branching; conidia hyaline, continuous, densely spirally convolute.

One species is described.

The *Knyarieae* might be divided into three groups, those like *Knyaria* and *Hymenella*, with well developed conidiophores and small, continuous or septate conidia; second, those genera with the conidiophores greatly reduced or wanting, comprising 7, 8, 9 and 10, and, finally, those with staurosporous or helicosporous conidia. But as these groups grade into one another the division has seemed unnecessary.

Tribe **Cylindrocolleae**.

Sporodochium globose, or verruciform, sessile, or substipitate; sporophore thin, elongated, generally much branched, hyaline, or fuscous; conidia simple, cylindrical, concolorous, catentate, the chains often branched.

15. **CYLINDROCOLLA** Bon. Handb. 149. 1851.

Sporodochium irregularly verruciform, gelatinous, bright-colored; sporophore filiform, multiramose; conidia simple, cylindrical, truncate, acrogenous, hyaline, or bright colored.

The species of this genus are for the most part conidial stages of *Calloria;* five species occur in this country.

16. **SPHAERIDIUM** Fres. Beitr. Myk. 46. 1852.

Sporodochium globose, subcarneous, not at all gelatinous, substipitate; sporophore as in *Cylindrocolla;* conidia elongate-cylindrical, hyaline, borne in simple, or branched chains.

Conidial stages of *Helotieae;* two species are reported for the United States.

Tribe **Volutelleae.**

Sporodochium disciform, or pulvinate, sessile, or stipitate, margin, rarely the entire sporophore, ciliate or setulose; sporophore simple, or sparingly branched, even obsolete and then, replaced by a stroma, hyaline or fuscous; conidia simple, or septate, single, rarely catenulate, acrogenous, hyaline, or fuscous.

17. **VOLUTELLA** Tode. Fung. Meckl. **1**: 28. 1790.

Sporodochium disciform, sessile, or stipitate, ciliate, bright-colored; sporophore typically simple; conidia simple, globose to ellipsoid, hyaline.

Represented in the United States by 12 species.

18. **VOLUTELLARIA** Sacc. Syll. Fung. **4**: 682. 1884.

Sporodochium pulvinate, sessile; sporophore obsolete; stroma sub cellular, ciliate; conidia simple, acervulate, ovoid, hyaline.

A monotypic genus, as yet found only in this country.

19. **CHAETOSTROMA** Corda. Sturm D. C. Fl. **2**:122. 1829.

Sporodochium disciform, margin ciliate or setulose with stout, septate, fuscous hairs distinct from the sporophores; sporophore simple, bacillar; conidia simple, typically single, ovate to fusoid, fuscous.

A single species of this genus has been reported for the United States.

20. **MYROTHECIUM** TODE. Fung. Meckl. **1**: 25. 1790.

Sporodochium disciform, or patellate, margined with thin, hyaline, continuous hyphae, similar to the sporophores; the latter usually branched, rarely bacillar; conidia oblong to cylindrical, simple, fuscous, often nearly hyaline.

This genus contains 4 American representatives.

Tribe **Fusarieae.**

Sporodochia pulvinate, verruciform, or sub-effuse, not setose or ciliate; conidiophores verticillately branched; conidia acrogenous, oblong, ovoid, fusoid, or falcate, continuous or septate.

21. **DENDRODOCHIUM.**

Sporodochia pulvinate or verruciform; conidiophores subverticillate; conidia elliptical or oblong, continuous.

This genus connects with *Knyaria* on the one hand and with *Fusarium* on the other. Six species are reported for North America.

22. **FUSARIUM** LK. Berl. Mag. **3**: 10. 1809.

Including *Fusisporium* LK. Obs. Myc. **1**: 17, and *Selerosporium* CORDA.

Sporodochia pulvinate, or effused; conidiophores verticillate; conidia fusoid or falcate, continuous or, usually, many-septate.

In *Eu-Fusarium* the sporodochia are pulvinate, while in *Fusisporium* they are effuse and are scarcely to be termed sporodochia. The latter is in many respects allied to *Trichoderma*, near which it was long placed. But it has been shown that the same species may assume either the pulvinate or the effuse type under varying conditions, thus rendering it practically impossible to maintain a distinction.

Fifty-six species are described or reported from North America.

23. **PIONNOTES** FR. Summ. Veg. Scand. 481. 1849.

Sporodochia gelatinous, becoming rigid, forming a thick, often lobed, mass; sporophores subverticellate, sometimes simple, fasciculate; conidia rather large, elliptical, cylindrical, or usually fusoid, curved, continuous or obsoletely septate.

Not very well distinguished from *Fusarium*. 2 species are reported for North America.

24. **MICROCERA** Desm. Ann. Sci. Nat. Bot. III. **10**:359. 1848.

Sporodochia conical or pulvinate; conidiophores filiform, subverticellate; conidia narrowly falcate, many-septate.

Not very well distinguished from *Fusarium*. One species is reported from North America.

Tribe **Trimmatostromeae.**

Sporodochium pulvinate, or disciform, fuscous; sporophores obsolescent or obsolete; stroma cellular when present, sometimes lacking; conidia catenulate, catenulae often branched, acervulate, simple to phragmosporous, fuscous.

25. **STRUMELLA** Fr. Summa Veg. Scand. **2**:482. 1849.

Sporodochium irregularly verruciform; sporophore very short, obsolescent; chains of conidia irregularly multiramose; conidia ovoid to fusoid, simple.

Five species of this anomalous genus occur in the United States.

26. **TRIMMATOSTROMA** Corda. Ic. Fung. **1**:9. 1837.

Sporodochium pulvinate, more or less carbonaceous; sporophore obsolete; conidia oblong, phragmosporous.

A single species is reported for this country.

XLV. ON SOME MOSSES AT HIGH ALTITUDES.

J. M. Holzinger.

During a short visit in Colorado, in June of 1896, it was my good fortune to be able to arrange an ascent of Pike's Peak on foot. On this trip I collected some interesting mosses at unusual elevations. The object of this note is to call the attention of all botanists who may have the opportunity to collect on top of this or similar high mountains to the fact that a considerably varied moss flora is thriving near and at its very top, and under conditions that would hardly warrant the expectation of a single species of moss. So far as the records of altitudes with collecting stations go to show, field workers had heretofore not looked for, and so had not collected mosses above 12,000 feet altitude. Indeed, few species are credited with an altitude greater than 8,000—10,000 feet, either in Europe or North America. Yet, my collection from above the Saddle House, altitude 12,502 ft., to the top of the peak, altitude 14,147 feet, has yielded over twenty-five species of mosses, nineteen of which I have been able to determine. My list is appended.

1. **Andreaea petrophila** Ehrh. Sterile and fruiting.

This moss occurs abundantly above 12,000 feet elevation on the red granitic boulders that make up the vast, bleak, convex pile of the top of Pike's Peak. Although I was on the sunny side of the top, and my visit occurred on June 7, this, and in fact all the rock mosses collected near the top, frequently occurred on the *under* side of the great rock masses, in close contact with the snow and ice, that finds a perennial home among these cyclopean masses of rock.

Along with what agrees fairly well with typical *Andreaea petrophila*, and especially near the top of the peak, I found sods that differed considerably from the usual forms, having the leaf margins strongly rolled in, showing in cross-section

papillae on *both* sides of the leaf, and *two cell layers* part way across the leaf. I had already decided to honor this bistratose character with a varietal name, when I came upon and took to heart Limpricht's remark under this very species. In his Laubmoose. **1**:140, he says: "In Bryol. eur. Schimper has afflicted with names a long series of forms (of *Andreaea petrophila*), and has figured them on *tab. 624, 625;* however, the arranging of an abundance of material in accordance therewith is a thankless task, for in this sense the circle of forms is without limit in every common species." At any rate, until I can have the opportunity of critically examining some of the Old World forms of this species, especially the high altitude forms, it seems best to let the plant rest under its old specific name.

2. **Cynodontium virens** var. **wahlenbergii** B. S. Sterile. Collected near the 13,000 feet level, with *Pogonatum alpinum.*

3. **Dicranum albicans** B. S. Sterile.
On ground, at an elevation of over 13,000 feet.

4. **Distichium capillaceum** (Sw.) Bry. eur. Sterile.
This is apparently the high-alpine, short-leafed form named var. *brevifolium* Bry. Eur. and referred to in Limpr. Laubm. p. 515. Collected above 13,000 feet. Not uncommon.

5. **Barbula fragilis** B. S. Sterile.
This plant is smaller than that occurring near Winona; but in all respects, otherwise, even to the broken leaf points, it agrees with it. Only one small sod was found at 13,000 feet.

6. **Barbula mucronifolia** B. S.
Occurred in two places near 13,000 feet altitude.

7. **Barbula mülleri** B. S. Sterile.
This determination is doubtful. The plants are smaller than usual, if it is this. Common from 13,000 to 14,000 feet.

8. **Grimmia apocarpa** Hedw.
Collected near the top of the mountain.

9. **Grimmia commutata** Hüb.
An abundant moss from 10,000 to 13,500 feet.

10. **Orthotrichum laevigatum** ZETT.

An abundantly fruiting plant, common from 13,000 to 14,000 feet. I had determined this as *O. Kingianum*, since there is in this moss a double peristome, the cilia being as long as the teeth, formed frequently of two rows of cells. But Mrs. E. G. Britton, our best authority on *Orthotrichum*, determined it as *O. laevigatum*.

11. **Orthotrichum** sp.

Only a small sod was collected of this plant. Mrs. Britton refers the plant to *O. Killiasii* C. M., with a doubt.

12. **Encalypta vulgaris** HEDW.

Only a little was collected of this species near the 13,000 feet level. But it is quite common from there down the mountain.

13. **Webera elongata** SCHW. Sterile.

At 13,000 feet to 13,500 feet altitude.

14. **Webera elongata** var. **humilis** SCH.

At about the same altitude, less common than the species.

15. **Webera nudicaulis** LESQ.

Above 13,000 feet altitude.
Another species of Webera was collected in considerable quantity, but is not identifiable, being sterile.

16. **Pogonatum alpinum** ROEHL. Sterile.

On ground at 13,000 feet altitude.

17. **Polytrichum strictum** MENZ. Sterile.

On ground, alone and mixed with *Distichium*, at 13,000 to 13,500 feet altitude.

18. **Polytrichum piliferum** SCHREB. Sterile.

Mixed with the sterile *Webera* mentioned under No. 15. At 13,000 feet elevation.

19. **Pseudoleskea rigescens** LINDB. Sterile.

Near the top of the peak, at 14,000 feet altitude. The plant was compared with material from Idaho collected by Dr. J. H. Sandberg in 1892, and agrees perfectly with it.

In addition to these 19 species, there is quite a quantity of material at hand from my collection, containing some 10 species more. So that Pike's Peak, at least, has in the last two thousand feet below its top, not less than 30 species of mosses which deserve attention at the hands of future collectors.

XLVI. THE FORCES DETERMINING THE POSITION OF DORSIVENTRAL LEAVES.

R. N. DAY.

The work described in the following paper was undertaken for the purpose of determination of the relative value of various forces operative in the production of the positions of dorsiventral leaves, and to what extent the inherited and spontaneous trophies of these organs might be altered by outward conditions.

A paper covering these points and embracing a review of the literature bearing upon the subject was published by Vines in 1890 (V). Vines' conclusions as given by himself are as follows:

"(1) Epinasty, and also hyponasty, are not induced, but are spontaneous movements; (2) dorsiventral members, so far as my experiments go, are not negatively geotropic, the movements hitherto described as negative geotropism being due to hyponasty, and altogether independent of gravitation."

As may be seen by reference to the results of my experiments, they confirm Vines' view of the general nature of epinasty and hyponasty, which is in direct opposition to that of Detmer. In the consideration of the second point in the summary given above, I am, of course, unable to comprehend exactly what is meant by "movements hitherto ascribed to negative geotropism." It seems reasonable to suppose, however, that reference is here made to the upward movements of leaves in darkness, —a conclusion which is not in harmony with the results described below.

Since the appearance of Vines' paper, Czapek (I) has published a most valuable contribution to our knowledge of the combined reactions of heliotropism and geotropism. The chief interest of his researches lies in the conclusion that the action of two

The work recorded in this paper was performed under the direction and by the aid of Prof. D. T. MacDougal.

stimuli—geotropic and heliotropic—upon an organ simultaneously in no wise affects the sensibility of the organ to each of these stimuli, in opposition to the theory of "Specific energy, of Müller, but that the reaction of one or the other may be mechanically suppressed, but not physiologically altered.

The results of Vines' (V) and Detmer's (II) investigations as to the nature of epinasty and hyponasty are so widely divergent, though obtained from the same material, that it was deemed advisable to repeat the detail of their experiments. To this end seeds of *Helianthus*, *Cucurbita*, and *Phaseolus* were germinated in a dark chamber, and subjected to various conditions. The cotyledons remained closely pressed together for a period of three to five days, but at the end of this time they began to separate, and about the eighth day exhibited a divergence of 120° to 135°. This experiment included a large number of individuals of each species, and great precautions were taken that all possibility of error be excluded. The exposure of the plants to light during the short time necessary for daily examination, was quite insufficient to vitiate the results. The results of this set of experiments verifies Vines' conclusions that epinasty is not induced by light, but may occur in darkness as well. The fact that the cotyledons did not move through an arc of 90° and attain a horizontal position is due to the fact that the plant was not in a phototonic condition. The epinastic growth shown by the cotyledons was clearly independent of light, and Detmer's photo-epinasty and hyponasty as such do not exist. Detmer's conclusions are repeated in the recent edition of his text book, and no reference is made to the contradictory results reached by Vines.

The remaining experiments, extending over a period of fourteen months, were devoted to the study of geotropism, heliotropism, and epinasty in dorsiventral members. The material used included one or more species of *Taraxacum*, *Helianthus*, *Nicotiana*, *Arisaema*, and *Lactuca*.

In the manipulation of the growing specimens it was found to be much more convenient if they were carefully removed from the pots in which they were grown, and the roots, with the adhering mass of earth wrapped in sphagnum moss. When prepared in this manner space sufficient for the movement of the leaves through an arc of 150° was obtained. The plants were allowed to recover from this transplantation before used for experimental purposes. In all of the experiments young, vigorously-growing specimens were used, and care was

exercised that the leaves had assumed their final position and balance of growth. This last precaution is quite essential since many radical leaves are hyponastic in earlier stages, and epinastic in later stages of development. At the end of each experiment the condition of the plant was noted, and if it was unhealthy or flaccid, results were disregarded. In every instance duplication of the experiment was made. The dark chamber used was constructed of zinc and was placed in the plant house in such position that the sunlight could not strike it. The temperature varied between 24° and 28° C.

DETAIL OF EXPERIMENTS.

Experiment 1.—A normal specimen of a rosette of *Taraxacum* obtained by germination of a seed three months previously was placed in an upright position in a dark chamber. Twenty-four hours later the younger leaves had begun to curve upward. Forty-eight hours later all the leaves were pointing upward. The vertical position might be due to hyponasty, or negative geotropism.

Experiment 2.—A specimen of *Taraxacum*, similar to that used in Exp. 1, was attached to the clinostat in a dark chamber in such manner that the axis of the root-stock was rotated while held in a horizontal position. Forty-eight hours after the beginning of the experiment, the leaves had assumed a position parallel to the axis of the root-stock. The position of the leaves in this instance was clearly due to hyponasty.

Experiment 3.—A specimen of *Taraxacum* was placed in the dark chamber with the root-stock in a horizontal position. Forty-eight hours later all of the leaves were at right angles to the root-stock and pointing upward. At the beginning of the experiment eight leaves held this position, and the same number were pointing in an opposite direction. In order to assume the upright position the last group moved through an arc of 180° In this, as well as all other experiments, no account was taken of torsions.

Experiment 4.—A specimen of *Taraxacum* was placed in the dark chamber in an inverted position, with the root-stock pointing upward, and the leaves horizontally with their dorsal surfaces below. Forty-eight hours later all of the leaves had curved upward into a position parallel with the root-stock.

Experiment 5. A plant of *Taraxacum* in a pot was placed in its normal upright position, where it could receive light from one side only. The leaves of the rosette on the side farthest from the source of light were curved upward at the end of the third day in such a manner as to place themselves perpendicular to the rays of light. Those leaves on the side of the rosette nearest the light remained in nearly their normal position.

Experiment 6.—A normal specimen of *Taraxacum* was placed in an inverted position in a dark chamber with strong sunlight thrown in the chamber from below, by means of a large mirror. The plant was kept in this position for a week, being well watered and cared for during the interval. At the end of seven days a few of the leaves exhibited slight torsions in response to the peculiar conditions of the light received, but the remainder held their relative positions as before.

The members of the rosette of *Taraxacum* are therefore diaheliotropic as shown by experiments 5 and 6, negatively geotropic as shown by experiments 3 and 4, and hyponastic as shown by experiments 1 and 2. The ordinary position of the leaves is therefore due to their diaheliotropism. The diaheliotropic irritability of the plant so much overbalances the other forms that their reactions are suppressed. When the heliotropic stimulus is removed the apogeotropic reaction is exhibited, and the hyponasty of the leaf is suppressed. If both the heliotropic and geotropic stimuli are removed the leaf assumes a hyponastic position. The result of this set of experiments supports the conclusion reached by Frank (IV), that the radical leaves of *Taraxacum* are apogeotropic. I am wholly unable to account for the discordance between the experiment of Vines (V, p. 426,) and experiments 3 and 4 of my own series, which were many times repeated.

NICOTIANA.

Experiment 7.—A healthy normal specimen of a rosette of *Nicotiana* growing in a pot was placed in an inverted position in a dark chamber, with the radical leaves horizontal. Forty-eight hours later the leaves were pointing directly upward.

Experiment 8.—A specimen of a rosette of *Nicotiana* similar to that used in Exp. 7 was placed in an inverted position in a dark chamber, with the radical leaves horizontal and the dorsal surfaces downward. Sixty hours later the leaves had assumed

a position parallel to the root-stock and pointing directly upward.

Experiment 9.—A specimen of a rosette of *Nicotiana* was placed in a dark chamber, with the root-stock in a horizontal position and the leaves in a vertical plane. Forty-eight hours later all the leaves were pointing upward.

Experiment 10.—A specimen of the rosette of *Nicotiana*, with the roots enclosed in sphagnum, was placed in a chamber in a natural position and light was allowed to enter from above and below, striking the under and upper surfaces of the leaves. Observations from time to time during a period of six days revealed no movements except by a few of the leaves in an effort to assume a position more nearly perpendicular to the light.

Experiment 11.—A specimen of *Nicotiana* prepared with sphagnum was placed in a dark chamber in an inverted position, with the root-stock pointing upward and the dorsal surfaces of the leaves facing downward. One week later no changes had taken place except those indicated in Exp. 10.

Experiment 12.—A specimen of *Nicotiana* prepared with sphagnum was attached to a clinostat, and rotated with the axis of the root-stock in horizontal, and the leaves in a vertical plane. Forty-eight hours later the leaves had curved toward the root, in a manner indicative of epinastic growth and exhibiting a behavior exactly contrary to *Taraxacum.*

Experiment 13.—A normal specimen of *Nicotiana* prepared with sphagnum was attached to a clinostat and rotated with the axis of the root-stock in a horizontal position, and its leaves in a vertical plane. Light was allowed to strike the plant at right angles to the root-stock and parallel to the surfaces of the leaves. Forty-eight hours later the leaves had curved toward the root in such manner as to exhibit their dorsal surfaces to the light as each in turn was brought opposite the opening in the dark chamber.

It may be seen by experiments 10, 11, and 13 that the members of the rosette of *Nicotiana* are diaheliotropic; by experiment 9 that they are apogeotropic; and by experiments 9 and 12 that they are epinastic. The degree of irritability to the three classes of stimuli decreases in the order named.

HELIANTHUS.

Experiment 14.—A young specimen of *Helianthus*, 40 cm. in height, was placed in the dark chamber in the normal upright position. Twenty-four hours later the leaves were noticeably curved downward, and 72 hours later the apices of all the younger leaves were pointing vertically downward. The change was not so marked in more mature organs. The same result was obtained by Vines (V, p. 422, fig. 8).

Experiment 15.—A young normal specimen of *Helianthus* was placed in a horizontal position with the stem bound firmly to a stick to prevent curvatures of anything except the leaves. Seventy-two hours later the leaves exhibited epinastic curvatures, pointing toward the root, in a manner generally similar to that described by Vines (V, p. 429), except that all were pointed in a basipetal direction. All the positions assumed by leaves previously extending horizontally from the stem were such that the dorsal surfaces were uppermost.

Experiment 16. The plant used in Exp. 15 was allowed to recover normal attitude and condition in sunlight, and then it was placed in an inverted position in the dark chamber. Forty hours later the leaves began to curve upward toward the roots, and the curvature became more pronounced 20 hours later.

Experiment 17.—A young normal plant of *Helianthus* was attached to a clinostat and rotated with its axis in a horizontal plane. During its rotation light was admitted at right angles to the stem. Twenty-four hours later the leaves were curved toward the root in such manner that the dorsal surfaces received the rays at right angles.

Experiment 18.—A young plant of *Helianthus* was placed in normal upright position until the leaves were epinastically curved. The plant was then inverted and illumination was then given from below, with the result that in four days the leaves had returned to their usual positions with respect to the stem, and with their dorsal surfaces at right angles to the rays. The results of the entire group of experiments agree with those obtained by Vines. The leaves of *Helianthus* are diaheliotropic, diageotropic, and epinastic.

ARISAEMA.

Experiment 19.—A plant of *Arisaema triphyllum*, recently emerged from the bud, was placed in an upright position in the dark chamber. At the end of 48 hours the leaflets had assumed an epinastic position, with the tips pointing downward.

Experiment 20.—A specimen of *Arisaema* was placed in a dark chamber in an inverted position with the laminae horizontal and the stem bound to a stick to prevent curvatures in that organ. Forty eight hours later the tips had moved upward through an arc of 30°-50°.

Experiment 21—A vigorously growing specimen of *Arisaema* was attached to a clinostat and rotated with the stem in a horizontal plane, and given an illumination from one side only. Ninety hours later all of the leaves had curved through an arc of 90°, and were parallel to the stem with the tips pointing toward the roots.

Experiment 22.—A young specimen of *Arisaema* was placed in an inverted position in a dark chamber and illuminated from below in such manner that the light struck the dorsal surfaces of the leaflets. At the end of a week no change in position had taken place.

Experiment 23.—Two specimens of *Arisaema*, as nearly alike as possible, were placed in the dark chamber, one in the normal upright position and the other inverted. No change in position except that due to epinasty was noticed in the leaves of either plant inside of a period of three days, and the angle of curvature was the same in both.

Experiment 24.—A specimen of *Arisaema* was placed in such a position in a dark chamber that the axis was horizontal and the leaf blades in a vertical plane. The tip of one leaflet pointed directly downward, while two others were directly upward, but with the long axis of the leaf directed 20° away from the vertical. Forty-eight hours later the leaflet pointing downward had risen through an arc of 75° and lay nearly horizontal, while the two remaining leaflets had curved downward to the horizontal position. These positions were retained four days later.

Experiment 25.—Etiolated specimens of *Arisaema* exhibited a great variety of positions of the leaflets, which seemed to be dependent entirely on the trophies. In such condition the

adaptive processes interfere in such manner as to render the results difficult of interpretation.

The foregoing experiments indicate that the leaflets of *Arisaema* are diaheliotropic, epinastic, and diageotropic.

LACTUCA.

Experiment 26.—A specimen of a rosette of *Lactuca scariola* was placed in a clinostat in a dark chamber, and rotated with its root-stock in a horizontal and the rosette members in a vertical plane. Illumination was given at right angles to the root-stock. Forty-eight hours later the radical leaves had curved backward and pointed toward the roots, in a manner indicative of diaheliotropism.

Experiment 27.—A specimen of the rosette of *Lactuca* was placed in the dark chamber in an inverted position. Twenty-four hours later all the leaves had curved upward toward the roots.

Experiment 28.—A specimen of *Lactuca* was placed in a dark chamber in an inverted position and illuminated from below. Four days later no noticeable change of position had occurred. Many torsions were to be seen, however.

Experiment 29.—A specimen of the rosette of *Lactuca* was attached to a clinostat, with the root-stock horizontal and the leaves in a vertical plane. Forty-eight hours later the leaves had curved toward the root.

Experiment 30.—A specimen of *Lactuca* was placed in a dark chamber in a horizontal position. Forty-eight hours later curvatures had begun, and seventy-two hours later all the leaves were pointing upward.

The curvatures of *Lactuca* are diaheliotropic, epinastic, and apogeotropic.

RECAPITULATION.

A consideration of the results of the foregoing experiments leads to the following conclusions:

I. The prevalence of an epinastic or hyponastic condition of growth in any organ is due entirely to internal causes and may be said to be spontaneous. In many plants leaves are epinastic in an earlier stage of growth, and hyponastic in a later one, or vice versa. The balance of the two forces may not be disturbed or initiated by external conditions. Light, there-

fore, cannot induce epinasty or hyponasty. This is in direct support of the position taken by Vines, and the results upon which it is based demonstrate that the *photo-epinasty* of Detmer does not exist as such.

II. All dorsiventral leaves are diaheliotropic.

III. Dorsiventral leaves may be diageotropic or apogeotropic. Radical leaves of *Lactuca*, *Taraxacum* and *Nicotiana* are apogeotropic, and those of *Helianthus* and *Arisaema* are diageotropic, a conclusion not in agreement with the results of Vines, who maintains that gravity may exert in such organs a diageotropic effect only.

IV. The ultimate position of dorsiventral leaves is a fixed light position, and the geotropic or trophic tendencies find no mechanical expression. The removal of the light stimulus from a plant, allows the unimpeded action of the other two forces. In some instances geotropism, in others, the trophic tendency, predominates. In no instance, however, has a resultant position, due to a mechanical equivalency of the two reactions, been observed.

V. The relative values of the geotropic and trophic tendencies are such that apogeotropism is generally stronger than hyponasty and epinasty, while epinasty or hyponasty are in turn stronger than diageotropism when occurring in the same organ.

VI. It is not possible to foresee the reaction of dorsiventral organs with reference to their present form or function. The geotropic tendency must have undergone serious alteration during the period of development of the species which resulted in the formation of rosettes, however. In these, as well as in stem leaves, the causes lie beyond the present circle of investigation.

TITLES TO WHICH REFERENCE IS MADE.

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II. **Detmer:** Ueber Photo-epinastie der Blätter. Bot. Ztg. 1882.

III. **Detmer:** Pflanzenphysiologische Prakticum 2nd ed. p. 427. 1895.

IV. **Frank, A. B.:** Die natürliche wagerechte Richtung von Pflanzentheilen, etc. 1870.

V. **Vines:** On Epinasty and Hyponasty. Ann. Bot. 3: 415–437. 1889–1890.

EXPLANATION OF PLATE.

PLATE XL.

1. *Taraxacum* grown in normal position in darkness. The young leaves are vertical or nearly so. The older leaves have remained in a position variously approximating the horizontal.

2. *Taraxacum* grown in inverted position in darkness. The younger leaves have curved toward the roots and grown vertically upward. The older leaves have approximately retained their original position.

XLVII. ON THE GENUS COSCINODON IN MINNESOTA.

J. M. HOLZINGER.

In my *Preliminary List of Mosses of Minnesota*,* I published the plant collected by me on the Catholic cemetery bluff at Winona as *Coscinodon raui* AUSTIN, with a note indicating uncertainty regarding this determination. This was published March 5, 1895. In the Bulletin of the Torrey Botanical Club of November, 1895, pp. 447–449, under *Contributions to American Bryology, XI*, Mrs. E. G. Britton states that the specimens collected by me on exposed sand bluffs at Winona, "have been determined by M. Cardot as *C. renauldi*," while she herself claims the determination as *C. raui*, following in this Professor Barnes, who some years before took the pains to compare the moss in question with some authentic *Coscinodon* material in the Cambridge Herbarium. So far as Mrs. Britton's reference to M. Cardot's determination is concerned, I desire to make a correction.

First, I stated in my list that M. Cardot had pronounced this species to be "*C. wrightii*, finding with it also *C. renauldi*." Then, under date of March 28, 1895, M. Cardot, after examining my list in MINNESOTA BOTANICAL STUDIES, writes to me on this point:

"The *Coscinodon* of Winona which you have sent to me, and which I have published in our exsiccati (No. 173), is surely *C. wrightii*, a species very distinct from *C. raui* and *C. renauldi*. But there were, in a mixed sod, some specimens of *C. renauldi*, which is, perhaps, not sufficiently distinct from *C. raui*." This is, of course, different from declaring the plant to be *C. renauldi*. But the last statement in my quotation from Cardot's letter has some additional interest, apart from its bearing on the plant in question: inasmuch as he here states, some eight months prior to Mrs. Britton's published note on

* Minn. Bot. Studies. **1**: 285.

"*Coscinodon raui* and *Coscinodon renauldi*," that his *C. renauldi* "is, perhaps, not sufficiently distinct from *C. raui*." The criticism of Cardot's species would doubtless have taken a different turn had his attitude regarding the plant been generally known. A most helpful feature, however, one for which all interested students owe a debt of gratitude to the writer, is the clearing up of errors made by the authors of the two species, Sullivant and Austin. In the light of these corrections the plants may now be thoroughly well understood.

From the dilemma regarding the right place of the little *Coscinodon* I was not extricated even when Mrs. Britton kindly loaned me type slides prepared from authentic material of *C. raui*, which I examined and returned to her March 30, 1895. She also kindly favored me with specimens of *C. raui* and *C. wrightii* collected near Rapid City, S. Dak., by Mrs. T. A. Williams, and *C. wrightii* collected in Nebraska by Mr. H. J. Webber. My method of examination was to remove some good leaves from a well soaked plant, make a water mount, and inspect critically the *surface* of the leaves with a $\frac{3}{4}$ in. and a $\frac{1}{5}$ in. objective. From the appearance of the leaves thus studied I could not arrive at a satisfactory conclusion. There were uniformly rectangular cells in the lower half of the leaves of all plants. The cells in the upper half were usually roundish, more thick-walled than below, but some leaves could be found on every plant that had the cells in the upper part more or less elongated, more so toward the costa, less toward the margin. Nor was the bleaching of the leaf apex, the erose-dentate margin in that part and the rounded leaf apex, a uniform character of either species. Some leaves on either species were hardly discolored at the apex, and then had the margin in that part entire; others were discolored in the entire upper third, and then were usually erose-dentate in that part. To be sure, the leaves of good *Coscinodon wrightii* were found to be, on the whole, more rounded at the apex, the long subula rising rather abruptly above them; but some of the upper leaves, at least in *C. raui*, are occasionally nearly as rounded, though the average leaf apex was more acute than in *C. wrightii*. Not even the diagnostic character laid down in Barnes' *Key* was found to hold for *C. raui*, which there has assigned to it a hyaline hair point shorter than the leaf. Mrs. Britton's correct figure of a leaf taken from type material tends to modify this diagnosis. And it is to be regretted that Barnes' new *Key*, issued January, 1897, has, after two years of tacit refutation of

this diagnostic character of *C. raui*, not offered a more distinctive diagnosis of the species. In my diagnosis of the plant under consideration I depended on Barnes' *Key*. Professor Barnes himself did not recognize the character in his determination of the plant, which has the upper leaves at least furnished with a slightly rough hyaline hair point much longer than the leaf, which gradually decreases in relative length, till near the rooting base of the stem the leaves are scale-like, appressed to the stem, very small, and the costa in the lower leaves cease below the rounded or barely apiculate apex.

In this uncertain condition the matter has rested for nearly two years. In May, 1896, I had the good fortune to collect some mosses in Colorado, the home of the types of *C. wrightii* and *C. raui*. By the very kind and generous arrangement of Professor Carl F. Baker, then of Colorado Agricultural College, Fort Collins, I enjoyed the exceptional facility of collecting for two days, with his guidance, and the use of a horse, wagon and driver, in some of the side cañons of Poudre river. While we were drenched both days by an incessant rain, and waded for miles up and down steep hills through the stickiest and yellowest Colorado clay, we secured our mosses all the more certainly because of the prevailing moisture. Under these favoring conditions a number of species, mostly very small mosses, were found by us on that trip; and among them, fortunately, two species of *Coscinodon*. Pressure of other duties has prevented me from working out this puzzle till recently. There is no difficulty at all in distinguishing the two species from each other with the naked eye, when one is sure of the genus from the presence of the *mitrate, plicate* calyptra. The gross distinction is as follows:

1. *Coscinodon wrightii* is silvery green, from the presence of the much lengthened hair points on the upper leaves, which stand erect; and this, with the more crowded condition of the plant, which forms small dense cushions, gives the lighter color.
2. *Coscinodon raui* has a more decided green tinge, there being fewer long hairs; the plants occur also usually less crowded, and in more extended patches.

In order to determine whether there was some tangible difference observable with the pocket lens, I moistened and separated several dozen plants of each species, washed out the sand and clay in which they are uniformly imbedded nearly to

the top, laid them out on glass slips, and let them dry. The appearance then, under the hand lens, left no shadow of doubt regarding the distinctness of the two plants. Disregarding the colorless subula of the leaves, which may or may not be longer than the leaf blade in *C. raui*, the plants are distinguished with the hand lens as follows:

1. *Coscinodon wrightii* has the more numerous hair points, *on the whole* longer, it is true, than in *C. raui;* is less branched, more delicate; the hair points, while diminishing in length toward the base of the stem, are distinctly present, and are about the middle of the new, developed stem still as long as the leaves (*Pl. XLI, figs. 8, 9*); leaves with hair points *erect-appressed*, the blades *distinctly spoon-shaped* all along the stem.
2. *Coscinodon raui* has fewer hair points, at least some of which may be twice the length of the leaf blade; is a more branching, somewhat coarser plant; the hair points discontinue below the upper third of the new, developed stem; the stem leaves are similar to near the base, are simply acute, *obliquely ascending, spreading*, with a *distinct keel* projecting on their under side.

These appearances changed my mind completely regarding the possible identity of the two species which I had entertained; here were two radically distinct plants, distinguishable without the aid of a compound microscope. And, after I carefully compared the plants with the descriptions in Lesquereux and James' *Manual*, giving also Mrs. Britton's corrections on the recorded observations of the two authors their proper weight, I had no reason to doubt that I had collected typical material of the two species, in *their type locality*, and in good quantity. I was now prepared to recur to the vexing Minnesota plant. Even before looking at it, I remembered that its gross appearance brought it nearer to *C. wrightii* than to *C. raui*. This was verified by an inspection. Then I washed out and separated a series of plants, and laid them out to dry on a glass slip. To be sure, the appearance of my plant under the hand lens did not associate it distinctly with either Colorado plant; for the new, developed stems were *not leafy* to near their base, and the leaves were not so distinctly spoon-shaped. Otherwise the plant was certainly nearer to *C. wrightii* than to *C. raui*, differing from *C. wrightii* principally in gross appearance

of the more naked lower part of the shorter stem, the leaves being more crowded toward the upper end. I began to think this might be a third species of *Coscinodon*, after all. But when I had looked up Cardot's letter, above quoted, in which he insists that this plant is *Coscinodon wrightii*, I was again at sea. And now I determined upon a critical examination of leaf-cross-sections, the result of which leaves no doubt regarding the relationship of our Minnesota *Coscinodons*, furnishing also absolutely reliable diagnostic characters of the two species.

I first proceeded to make leaf sections of the two Colorado plants, with the following results:

1. *Coscinodon wrightii* yielded leaf sections uniformly and evenly concave, in which the costa projected nearly evenly above and below the leaf surface; toward the apex the costa is restricted to the outer, under side of the leaf; in both sections a single row of large cells lies across the *upper surface*, continuous with the leaf cells. See *Pl. XLI, fig. 3*.
2. *Coscinodon raui* has a deeply furrowed costa, as is shown by *fig. 12*. This form of the costa doubtless gives the rigid divergent appearance to the stem leaves of *C. raui* under the hand lens. That the furrow extends even some distance into the colorless awn of this species is made apparent under the low power of the microscope by the occasional accumulation of soil in this groove, a condition frequently observed in this plant. Such an appearance never occurs in *C. wrightii*, which, judging from the leaf sections, has probably no such groove in the hair points of its leaves.

With this diagnosis worked out, I made a similar examination of cross sections of the Minnesota plant. And, judging from this character, there can be no doubt but that it should be referred to *C. wrightii* rather than to *C. raui*, its leaf sections being exactly like those of *C. wrightii* from Colorado. But there was still a recognizable difference in the gross appearance of my Minnesota plant, a difference uniform in all my material, and which I established by a series of examinations. This, in my judgment, justifies the Minnesota plant to be designated as a variety of *C. wrightii*, for which I propose the name—

Coscinodon wrightii var. **brevis** n. var.

Monoecious, like the species; simple or branching, one of the branches usually terminating in the antheridial, the other in the archegonial bud; leaves crowded toward the top of the stem into a tumid bud, rapidly reduced to scales, so that the stem below the middle is nearly naked; leaves not distinctly spoon-shaped under the hand lens as in the Colorado plant.

The examination into the occurrence of the sexual organs of the two forms of *Coscinodon wrightii* shows no essential differences between the two plants. I have made drawings of both organs with adjacent leaves also of the Colorado plant, which, on comparison with those taken from the Colorado plant, show incidentally that the *hair points* of the archegonial leaves are developed before the lamina; while the antheridial leaves are principally laminae with only a short costa, or with none at all, and may or may not have an incipient subula, or a short acumen.

In closing, I give my diagnosis of the North American species of *Coscinodon* so far as known at present:

Genus Coscinodon. Leaves appear as in *Grimmia;* but the capsule is half-covered by a mitrate folded calyptra as in *Orthotrichum.*

1. Plants dioecious, - - - - - - - - - - *C. pulvinatus.*
Alaska, British Columbia.

2. Plants monoecious,
   a. Costa in cross section deeply furrowed, stem leaves diverging and appearing keeled under a hand lens, - - *C. raui.*
   Arizona, Colorada, South Dakota, Minnesota.

   aa. Costa in cross section not furrowed, either equally projecting above and below the lamina, or in upper part of the leaf restricted to the back,

   b. Developed fruiting stems equally leafy to near base, the leaves to *below middle* of stem hair-pointed, and under hand lens distinctly *spoon-shaped,* - - - - - - - *C. wrightii.*
   Colorado, North Dakota.

   bb. Developed fruiting stems leafless for some distance above the rooting base, only some closely appressed scales representing the leaves there; hair-pointed leaves all crowded to near the top; no distinct appearance of spoon-shaped leaves,
   C. wrightii var. *brevis.*
   Minnesota.

Since completing the above paper a note should be added. *Coscinodon raui*, it should be stated, has been collected by me near Winona, but on the Wisconsin side of the Mississippi. My material is dated July 16, 1895. But all the material from the first station, the Catholic cemetery bluff, which is now in my hands, is unmixed *Coscinodon wrightii* var. *brevis*.

Through the kindness of Professor C. R. Barnes I was permitted to re-examine a part of his material from near Winona, sent him by me; all of it proved to be *Coscinodon wrightii* var. *brevis*. But Mrs. E. G. Britton's material from the same station, a part of which she also kindly sent me since writing the above, undoubtedly contains the two. It is therefore very probable that Professor Barnes' specimen was also mixed, and that, in his certainly very careful examination and comparison with the Cambridge type, he happened to have in hand some *Coscinodon raui* from the Minnesota material. Finally, a re-examination of all of Prof. Barnes' material disclosed some plants of *C. raui* growing together with *C. wrightii* var. *brevis*.

EXPLANATION OF PLATE.

PLATE XLI.

Fig. 1. Enlarged plant of *C. raui*, calyptra and peristome. X4.
Fig. 2. Enlarged plant of *C. wrightii*. X4.
Fig. 3. Enlarged plant of *C. wrightii* var. *brevis*, showing position of female bud and male bud. X4.
Fig. 4. Leaf of *C. raui* from upper portion of stem, front view. X42.
Fig. 5. Same, side view. X42.
Fig. 6. Leaf of *C. raui* from lower portion of stem, front view. X42.
Fig. 7. Same, side view. X42.
Fig. 8. Leaf of *C. wrightii* from upper portion of stem, front view. X42.
Fig. 9. Same, side view. X42.
Fig. 10. Leaf of *C. wrightii* from lower portion of stem, front view. X42.
Fig. 11. Same, side view. X42.
Fig. 12. Cross section of leaf of *C. raui*. X120.
Fig. 13. Same, *C. wrightii*. X120.
Fig. 14. Leaf of *C. wrightii*, showing areolation. X112.
Fig. 15. Same, *C. raui*. X112.
Fig. 16. Female flower of *C. wrightii* var. *brevis*, with two perichaetial leaves. X42.
Fig. 17. Male flower of same, with three perichaetial leaves. X42.

XLVIII. OBSERVATIONS ON THE FERNS AND FLOWERING PLANTS OF THE HAWAIIAN ISLANDS.*

A. A. HELLER.

The Hawaiian group of islands has long been known as possessing peculiar botanical features, and has been visited during the past one hundred years by a number of botanists, the first of whom was David Nelson, who collected there in 1778 and 1779, during the third voyage of Captain Cook.

The principal published accounts of Hawaiian plants are by Chamisso, in *Linnaea;* by Gaudichaud, in *Botanique du Voyage de l'Uranie*, incorrectly cited by Mann and Hillebrand as *Bot. Freyc. Voy.;* by Meyen, in *Nov. Act. Acad. Caes. Leop. Carol. Nat. Cur.;* by Asa Gray, in the *Botany of the U. S. Exploring Expedition*, and in the *Proceedings of the American Academy of Arts and Sciences;* by Nuttall, in the *Transactions of the American Philosophical Society;* by Horace Mann, in the *Proceedings of the Boston Society of Natural History*, and *Proceedings of the American Academy;* by Wawra, in *Flora*, and by Hillebrand, in his *Flora of the Hawaiian Islands.* Gaudichaud also issued a folio atlas, in which are plates of the plants collected on the voyage of the *Bonite*, but unaccompanied by descriptions. The Hawaiian plants to which these plates refer have mostly been described by different writers, and credited to Gaudichaud.

The main part of the group, composed of the islands of Hawaii, Maui, Kahoolawe, Lanai, Molokai, Oahu, Kauai, and Niihau, is situated between 18° 55′ and 22° 20′ N., and 154° 50′ and 160° 40′ W. Scattered in a northwesterly direction for a distance of 600 or 700 miles, are occasional rocks and small, low islands, now belonging to the young republic. Of these, Laysan island is perhaps the largest, though only a narrow strip of land a few miles long. It is of value only on account

* A complete series of this collection, amounting to over one thousand specimens of ferns and flowering plants, and including some sixty type specimens, has been presented by Mr. A. A. Heller to the herbarium of the Geological and Natural History Survey. The whole makes an addition of quite inestimable value to the state collections.—*C. M.*

of its large guano deposits The plants found on it are the same as those which occur along the beach on the lee sides of Oahu and Kauai, as *Gossypium tomentosum* and *Scaevola koenigii.*

Kauai, the third in size, is the oldest in point of formation, and usually considered to be the best botanically. On the lee side, separated by a channel nine miles in width, is Niihau, a small and rather low island, the maximum height not exceeding 1,000 feet. In the early part of the century it was of considerably more importance than now, as ships were accustomed to put in there to get a supply of yams, which were very abundant. There also the famous Niihau mats were made from *Cyperus laevigatus.*

Following the trend of formation from northwest to southeast, Oahu, the fourth island in size, comes next, separated from Kauai by a channel sixty miles in width.

Next in order is Molokai, fifth in size. It is a long, narrow island, with precipitous cliffs along the windward side. Conflicting statements are made as to the height of the mountains on this island, some giving 3,500 feet as the maximum, others 6,000 feet The highest, and consequently the wettest portion, is toward the eastern end. The western end is composed of the ancient crater of Maunolaa. On a small peninsula, which juts out near the middle on the north side of the island, is situated the leper settlement. This point of land is cut off from the main portion of the island by a *pali*, as precipices are there called. This pali is about 3,000 feet high, and practically impassable, so that the only approach is by sea. Some years ago the lepers, or as many of them as could be captured, were sent off to Molokai, and now, whenever a case develops, the victim is promptly sent there too. The government provides them with habitations, food and medical attendance, so that many of them are really much better off than they were before. This method has undoubtedly done much to check the spread of the dread disease.

Immediately south of Molokai, separated by a narrow channel, is Lanai, a small island, with a maximum elevation of perhaps 2,500 feet. Lying as it does on the lee side of Molokai and Maui, it receives but a small amount of moisture, and has only one permanent stream of water.

Just east of Lanai, lies Maui, the second in size of the group. It is composed of two mountains, connected by a low, sandy isthmus. The western part consists of precipitous mountain ridges, while the larger eastern part is occupied by the great

mountain of Haleakala, 10,000 feet high. The slope of this mountain, at least on the western side, is easy and gradual. The immense extinct crater of Haleakala—"House of the Sun"—is the largest in the world. It is triangular in shape, and from 1,000 to 2,000 feet deep.

Kahoolawe, southwest of Maui, is a small, barren island, devoted to sheep raising, and has never been considered of much interest botanically.

Last, but not least, for it is the largest, is the island of Hawaii, from which the group derives its name. It is 100 miles long and 90 miles wide. The northern end is occupied by the Kohala range of mountains, with a height of 6,000 feet. The remainder of the island is composed of three peaks, Mauna Kea, 13,805 feet high; Mauna Loa, 13,675 feet, and Hualalai, 8,273 feet. These three mountains form the three points of an equilateral triangle, with an elevated plateau of from 5,000 to 6,000 feet between them. On the southeastern slope of Mauna Loa, at 4,041 feet, is the famous crater of Kilauea.

Considering their proximity to the Equator, the Hawaiian islands enjoy an unusually mild climate, the mean annual temperature at Honolulu being about 79° F. The minimum is 50° F. and maximum 90° F., but the latter figure is rarely reached. The northeast trade winds, which blow during about three-fourths of the year, are the cause of the pleasant and equitable temperature. During the winter months, when the wind shifts to the south or southeast, bringing with it some of the equatorial heat and sultriness, is the most disagreeable time of the year. This is the season, too, when the heavy "Kona" storms of wind and rain usually make their appearance.

The topography has much to do with the rainfall, as the islands are practically all mountains, with very little low land along the coast. In nearly all cases a mountain barrier being presented to the prevailing wind, the moisture is condensed, and a heavy precipitation follows on the windward side, while the lee side may be comparatively rainless. At Hilo, on Hawaii, and at Hanalei, on Kauai, the average rainfall is 180 inches, while at points opposite on the lee sides of the same islands, the average is about 25 inches.

As the soil is composed of disintegrated lava rock, it is very porous, and very little water can be found on and near mountain summits, although there are exceptions on Maui and Kauai, where bogs have been formed. Usually the rainfall which is precipitated on the summits and upper slopes, percolates

through the soil and makes its appearance as streams somewhere upon the lower slopes of the mountains, or wells up as springs on the beach. Along the beach, between Diamond Head and Koko Head, on Oahu, in a region where rain rarely falls except in winter, are a number of springs of fresh water, covered at high tide by the sea. Just beyond Diamond Head it is a common sight to see cattle go down to the beach, and apparently take a drink of salt water.

Judging from the uniformity of the geological formation, we should expect a great similarity in the vegetation of the several islands, but such is not the case. True, there are many species common to all of the islands, but the bulk of the native species found on any given island, are different from those which occur on the other islands, and when a species is found on two or more islands, it differs somewhat in leaf form, or in some other particular. This is especially true of strictly endemic plants. The introduced species show a much greater uniformity in habit and growth.

Isolated from a continental area, and almost equally so from the other islands of the Polynesian system, Hawaiian vegetation has developed independent of extraneous modifying conditions. That it has done so in a satisfactory way, is evinced by a summing up of the proportion of endemic species in Hillebrand's *Flora.* This work, published in 1888, enumerates 999 species of phanerogams and vascular cryptogams. Of this number, 139 are introduced, and 653 are endemic, leaving 207 native species which are found elsewhere.

Of the 653 endemic species, 250 belong to 40 endemic genera. These endemic genera are found principally among the Rubiaceae, Compositae, Lobeliaceae, and Labiatae. The distribution of the species in the larger of these endemic genera is quite interesting.

Schiedia is represented on all of the islands, but principally on the northern islands of Kauai and Oahu. The same holds good, too, with *Pelea* and *Platydesma*.

Of the Araliaceae, *Cheirodendron* is pretty well divided. *Dipanax* is northern, one species out of three being found on Lanai. *Triplasandra* is confined almost exclusively to Oahu.

Of the Rubiaceae, *Kadua*, *Gouldia*, *Bobea*, and *Straussia* are distributed over all of the islands, but Hawaii has a smaller number than the other islands.

In the Compositae, *Remya* is found on Kauai and Maui, with no species recorded from the intermediate island of Oahu.

Tetramolopium ranges over all of the islands, but is most abundant on Maui and Hawaii, only one species finding its way to Kauai. *Lipochaeta*, which may be considered a Hawaiian genus, ranges over all of the islands, but principally from Hawaii to Oahu. The same may be said of *Campylotheca*. *Argyroxiphium* is confined to the high mountains of Maui and Hawaii. *Wilkesia* is represented by two species, one on Kauai, and one on Maui. *Dubautia* is confined principally to Kauai, four of the six species being found there, while none occur on Hawaii. *Raillardia*, on the contrary, is found principally on Hawaii, with one species on Kauai. *Hesperomannia* is of central distribution, occurring on Lanai Maui, and Oahu.

In the Lobeliaceae, *Clermontia* is of central distribution, few species being found on Kauai and Hawaii. *Rollandia* is found only on Oahu. *Dellissea* is northern in range, growing principally on Oahu and Kauai, with one species on Hawaii. *Cyanea*, with about thirty species, occurs on all of the islands, but is most abundant on the islands of Maui and Hawaii, thus being principally of southern distribution.

Of the Labiatae, *Haplostachys* is central or southern, ranging from Molokai to Hawaii, with a form on Kauai. *Phyllostegia* predominates on Hawaii and Maui, with a few species on Molokai, Oahu, and Kauai. The same is true of *Sphacele*, except that even fewer species are found on the northern islands.

Besides these larger genera, there are smaller ones, which have representatives only on the northern islands, and when they are taken into account, the endemic species are found to be pretty evenly distributed over the entire group. But we also find that in the larger and more differentiated genera, the greatest number of species are found on the later formed islands of Maui and Hawaii, where also the greatest elevations are found.

The great number of ferns appeal to the eye of the botanist, when he ascends to the region of native vegetation. Omitting the lower cryptogams, they comprise one-sixth of the native vegetation. The comparative scarcity of grasses, Compositae, and Leguminosae, in opposition to the unusually large number of Rutaceae, Rubiaceae, Lobeliaceae, and Labiatae, is a matter of astonishment to the collector from more temperate regions.

To the student of the lower cryptogams, an immense field is open. Near the summits of the mountains, and in other places where there is a large amount of moisture, the trees, bushes

and ground are draped and carpeted with mosses and Hepatics. Lichens seem to be most abundant on the trees and rocks of the lower and middle regions, at least on Oahu and Kauai. *Aleurites moluccana*, the "Kukui" tree, which flourishes only in the lower forest region, is the host of more species of lichens than perhaps any other tree. Next comes *Acacia Koa*, the "Koa" tree, which harbors many interesting species, but, as a rule, different from those which are found on the Kukui tree. Parasitic fungi are common on the leaves and stalks of many plants, but fleshy fungi seem to be scarce. Marine algae are abundant, as one would expect, and fresh water forms are probably plentiful in suitable situations

In the remarks concerning the geographical features of the islands, Oahu and Kauai were purposely omitted, or merely mentioned, in order to speak of them later, as they are the only islands which were visited by the writer.

Oahu, the fourth island in size, upon which is situated the capital city of Honolulu, is about thirty-five miles long, and twenty five miles wide at the point of its greatest breadth. The eastern portion, beginning at a point just west of Honolulu, is only ten or twelve miles wide. Two mountain ranges traverse the length of the island, the main range skirting the northeastern coast, and the Wainai range following the northwestern coast. Between these two ranges is a stretch of low land, which is often very dry, and hot.

Judging from the contour of the main range, the windward side, at least as far north as Ka Oio point, must once have been the rim of a vast crater. It presents a wall with a sheer descent of from 1,000 to 2,500 feet, all along between Makapuu and Ka Oio points. Rock walls like this, or precipices of all sorts, are called *pali* in the Kanaka, or Hawaiian languge. At the head of Nuuanu valley, is the only pass where it is possible to make a road across the mountain. This point, which is 1,200 feet above sea level, is always spoken of as *the Pali*. Here a small ridge projects toward the windward side, and by making use of this slope, a steep, zigzag road has been cut, which leads to the plain below. Here, on either side of Nuuanu valley, are the two high peaks of the main range, Konahuanui on the east side, and Waiolani on the west side. The former has an elevation of about 3,500 feet, the latter of 3,700 feet. On the Konahuanui side, the ridges all have steep slopes, but on the Waiolani side, especially near the extreme northwestern end, they spread out and become rather broad. The largest streams on the island rise here.

As mentioned above, the windward side of the range is a precipice, but on the lee side the conditions are different. Here numerous narrow ridges jut out, with deep valleys between. The sides of these ridges are so steep, that they are entirely inaccessible at most places. The lower ends, however, slope gradually toward the sea, so that by following along the backbone, one can ascend to the main ridge, although this is accomplished only by great labor, difficulty, and danger, as a misstep in some places would mean a plunge of 1,000 feet into the valley below.

The Waianae range extends along the shorter western coast. Its highest point is flat-topped Mt. Kaala, which has an elevation of 4,000 feet, and is the highest point on the island.

Although the subterranean fires were extinguished ages since on this island, there is abundant evidence to show that there once was great volcanic activity. There are four tufa cones in the vicinity of Honolulu. A short distance west of the city is the twin crater of Moanalua, containing a lake of salt water, which does not appear to be connected with the ocean. Punchbowl stands like a sentinel on the northeastern edge of the city. Diamond Head, the most imposing of the four, is four miles east. It has a height of 700 feet. Four or five miles beyond, near the extreme eastern end of the island, is Koko Head. A short distance beyond Diamond Head, are the remains of an ancient lava flow, where the immense black rocks are piled up in picturesque confusion. Just opposite, on the heights of Palolo, are the remains of a crater, and probably this flow emonated from thence, although there is not much trace of it in the intervening low ground.

This open country, or "lowland zone," as Hillebrand calls it, is almost rainless during the greater part of the year, and has few native species. It is the home of introduced species, a number of which are annuals, and spring up after the winter rains. In the dry and dusty regions, both east and west of Honolulu, the Algaroba tree, a species of *Prosopis*, flourishes, as do also large numbers of *Acacia farnesiana*, which here is always a shrub. *Opuntia tuna* is a familiar figure of the landscape. *Argemone mexicana* has all the appearance of an introduced plant, yet it must be a native, as it was found on the Islands when Captain Cook first touched there.

Lantana camara is perhaps the most noxious of all the introduced plants. It has spread over all of the islands of the group, and rendered useless many acres of pasture land.

To the 139 introduced species enumerated by Hillebrand, some 20 more have been added by the writer. The bulk of them were collected in the vicinity of Honolulu.

Of the few native trees mentioned as growing in the lowland zone, *Erythrina monosperma* and *Reynoldsia Sandwichensis* appear to have become extinct, at least on the eastern side of the island. On this island, the five zones into which Hillebrand divides the flora of the Islands, are not very applicable. The lowland and lower forest zones are distinct enough. The latter, characterized by the Kukui tree, ascends to between 1,500 to 2,000 feet. *Polypodium pellucidum*, which Hillebrand records as occurring in the fourth, or upper forest zone, I have found only in the lower zone. The other forms of higher elevations, are all referable to new species, described in this paper.

The third, or middle forest zone, extends to the summits of the mountains. In this zone it is said that "the prevailing trees are indeed *Metrosideros polymorpha* and *Acacia Koa*, but, although they reach here their greatest development in size and number, they are not confined to this zone, but extend above, and descend below it." On the contrary *Acacia Koa* is here more fully developed within the lower forest, and extends very little above it. *Metrosideros* is found sparingly in the lower forest, but is nowhere of any size, and higher is inclined to be shrubby. As the summits are approached, it disappears altogether.

The upper forest zone, as limited by Hillebrand, and the bog flora seem to be altogether wanting.

The flora of Oahu may be divided primarily into two divisions, that of the lowland, and that of the mountains. It is possible that the former may again be divided into windward lowland flora and lee side lowland flora, but as I did not collect on the windward side, this is a mere matter of conjecture. The mountain flora falls into three divisions. Two of these are found on the main range, and the third is on the Waianae range. The broad, low valley of Nuuanu, with the deep gap at the Pali, prevents the spread of species along the entire length of the main range, thus forming the boundary line of two floral areas. Many species grow on the east side of Nuuanu, which do not occur on the mountains on the west side, and *vice versa*.

Another peculiarity about the distribution of species, is that a species may occur in any given valley, but is not found in the valleys adjacent. One explanation of this fact may be that

they are not species which are capable of ascending high enough to cross the ridge, and the conditions are such that they cannot extend along the sides, and thus work around the ends.

The parts explored are only a small proportion of the whole island. The little valley of Pauoa, back of Honolulu, and the heights above it, received the most attention, especially the slopes of Konahuanui, which overlook upper Pauoa and Monoa valleys. Monoa valley itself was not explored. Some work was also done on the western slope of Makiki, and on "Tantalus," just above. Several trips were made up Nuuanu valley to the Pali, one about half way up Waiolani, one up Kalihi valley to its head, and several to the region of Diamond Head. One trip was also made to Pearl river. Marine algae were collected at Diamond Head and on the coral reef at one side of Honolulu harbor.

About four months were spent on the island of Kauai, the most northern of the group, and credited with having the most attractions for the botanical collector. This island is almost circular in outline, and enjoys the distinction of often having an annual rainfall of 200 inches at Hanalei, on the windward side, while Waimea, on the lee side, is one of the hottest and driest places on the group. The highest point is Mt. Waialeale, situated a little east of the centre. It is credited with an elevation of 6,000 feet, but in reality is under 5,000 feet.

The configuration of the island is very different from that of Oahu. Instead of a long main ridge, with secondary ridges branching out at right angles there is a central elevation in Mt. Waialeale, with ridges radiating from it in all directions, something like the spokes of a wheel. These ridges, at least their lower portions, are broad, and easy of ascent. There is usually a good trail along the backbone of each ridge, made by the wild cattle, which are numerous, and range through the forest everywhere. The lower limit of the forest is at much greater elevations here than on the island of Oahu. It is about 700 feet in Hanapepe valley, which is situated beneath Waialeale, and enjoys considerable rainfall, while above Waimea, it is almost 4,000 feet. The point, then, to which the forest descends, depends upon the proximity to the central high point, and to the windward rainy side.

There are three, and perhaps four distinct floral areas on the lee side of the island, but as my explorations did not extend to

the table land on the west side of the Waimea river, I cannot vouch for the fourth.

The deep cañon of the Hanapepe river, which cuts into the heart of the island, constitutes the dividing line between two of these floral areas. To the east of it lies a high, heavily timbered tract, with the lower limit of the forest at about 2,000 feet. Back, and a little southeast of Hanapepe falls, at an elevation of 3,000 feet, is a bog, situated in an ancient crater, the wall of which is broken down on the west side, and flanked there by wet woods. The Wahiawa river has its source in this bog. The Wahiawa does not cut deep enough in the upper part of its course to hinder the spread of species in an easterly direction. The flora of this region is essentially different from that on the west side of the Hanapepe cañon.

The second area is situated between the Hanapepe and the east fork of the Waimea river, which also cuts deeply in towards the centre of the island. This tract is somewhat subdivided by the main tributary of the Hanapepe, which has eroded a deep cañon opposite Gay & Robinson's house. This stream, like the Wahiawa, does not cut deep enough near its sources to make an impassible barrier to the spread of the species, and many species are found in common on the ridges on either side. This second area is, as a whole, much drier than the first one.

The third area is situated between the deep cañons of the east and west forks of the Waimea river. Here the forest proper does not begin until an elevation of 4,000 feet is reached. The timbered portion is mostly made up of a broad plateau, which ends abruptly on the southern, or Waimea side, and is sometimes called the "tabular summit." Somewhere on this plateau back towards Waialeale, is located an extensive bog, the "Lehua makanoe" of the natives. Near the edge of the plateau is where we find *Wilkesia*, *Raillardia latifolia*, *Cyanea leptostegia*, and other endemic Hawaiian species.

Kauai gets the credit of being the best botanical ground on the islands, but perhaps it is because collectors have spent less time there than on some of the other islands. Mr. Perkins, who has visited the entire group, while collecting birds and insects for the British Museum, tells me that he considers Molokai the best collecting ground. Although not a botanist, he is a keen observer, and as many insects are found only on certain plants, he has become acquainted with many of the native species. From my own observation, I would say that

the island of Oahu is perhaps as good collecting ground as Kauai.

There is no doubt but that Hillebrand's sum total of 999 species of flowering plants and ferns is entirely too small. My own explorations covered only a small part of the lee side of Oahu and less than half of the lee side of Kauai, yet these limited areas have yielded 500 species, in round numbers. Taking into consideration that the native flora of any given island of the group is different practically from that of the other islands, it is safe to say that careful study of the flora in the field, will increase the sum total to at least 2,000 species.

In describing the new species, I have taken a certain number as the type, and described only the specimen under that number. When a slightly different form, but undoubtedly the same species was collected, I have not made my description of the type to include that also, but refer it to the same species, and point out in what particulars it differs from the type. Much mischief has been done by mixed descriptions including several forms, but it is to be hoped that such a faulty practice will be discarded by every botanist.

I wish to express my thanks to Professor Wm. T. Brigham, Curator of the Bernice Pauahi Bishop Museum at Honolulu, for many kindnesses which made pleasant my stay in Honolulu, and also for the privilege of consulting the Mann & Brigham collection, preserved in the Museum. Here I was able to verify many of my specimens, and received much aid in determining others. To Mr. Francis Gay, of Makaweli, Kauai, I am much indebted for the privilege of occupying the Gay & Robinson house in Hanapepe valley, and the Kaholuamano house on the plateau, above Waimea.

The drawings for the plates were made by my wife, Mrs. E. Gertrude Heller, who has greatly aided in the preparation of this paper.

FILICALES.*

OPHIOGLOSSACEAE.

OPHIOGLOSSUM L. Sp. Pl. 1062. 1753.

Ophioglossum pendulum L. Sp. Pl. 1062. 1753.

On reclining tree trunks and protruding roots, never at any distance from the ground, in woods above Manoa, Oahu, at 2000–2500 feet elevation.

April to November (2217).

POLYPODIACEAE.

ACROSTICHUM L. Sp. Pl. 1067. 1753.

Acrostichum conforme Swz. Syn. Fil. **10**:192, *pl. 1, f. 1.* 1806.

Hillebrand says this fern is "rather rare." On the plateau above Waimea, Kauai, it is plentiful at 4000 feet elevation, growing either on the ground or on trees. It was not seen at lower elevations, and apparently does not occur on Oahu on the main range.

October (2808).

Acrostichum gorgoneum Kaulf. Enum. Fil. 63. 1824.

First collected in wet wood between the Wahiawa and Hanapepe rivers, at about 2000 feet elevation, where it is rather common, growing on the ground and rotten logs. It is also common at 2000 feet in similar situations above Manoa and Pauoa, Oahu. Above Waimea, Kauai, only a few plants were seen, at 4000 feet elevation.

July to November (2622).

Acrostichum helleri Underw. n. sp. *(Plate XLII.)*

Rootstock stout, creeping, densely covered with dark brown, crisped scales; petioles of sterile leaves rising at intervals of about 1 cm., 2–3 cm. long, naked, stramineous; sterile leaves 20–25 cm. long, 3–4 cm. wide, blunt at the apex, tapering toward the base, the margin entire; texture coriaceous; veins free, once or occasionally twice forked, about 1 mm. apart; surfaces smooth, glaucous green; petiole of spore bearing leaf 8–10 cm. long, gradually margined by the narrow leaf which is about the length of the sterile one but only 2–5 cm. wide, tapering gradually upwards, the apex somewhat acute and the margin recurved.

* The determination and synonomy by Professor Lucien M. Underwood.

Growing on trees at altitudes of about 3500 to 4000 feet, above Waimea, on the ridge west of the Hanapepe river, and near the head of the Wahiawa, Kauai.

This finely marked species belongs to the § *Elaphoglossum*, but has the texture of *A. reticulatum*. According to Mr. Heller, it "grows on upright trees, from ten to twenty feet from the ground, and grows around the trees. The thick, hairy rootstocks seem to be an accumulating place for dirt and eventually a disk is formed completely around the tree, usually extending out at least six inches from it. * * * It does not occur below 3000 feet and is most plentiful at about 3500 feet."

August to October (2709).

Acrostichum micradenium FÉE, Acrost. 43, *pl. 8, f. 1.* 1844.

On logs and tree trunks in damp woods, near the Wahiawa river, Kauai, at 2500 feet elevation, where it is rather common, though not observed at higher elevations. On Konahuanui and Waiolani, Oahu, it is found at 2500 feet and lower, but was not seen near the summits.

July (2621).

Acrostichum reticulatum KAULF. Enum. Fil. 64. 1824.

On reclining tree trunks. Common near the Wahiawa river, Kauai, at 2500 to 3000 feet, and above Manoa and Pauoa, Oahu, at 2000 to 2500 feet.

July to November (2114, 2567).

Acrostichum squamosum SWZ. Schrader's Journ. 2:11. 1800.

About the bases of trees, on the ridge west of the Hanapepe river, at 3000 feet, and at 4000 feet above Waimea, Kauai, on the banks of streams in the woods.

July to October (2688).

ADIANTUM L. Sp. Pl. 1094. 1753.

Adiantum capillus-veneris L. Sp. Pl. 1096. 1753.

Along the Hanapepe river and its tributaries, island of Kauai, growing plentifully on wet rocks. Also along the Wahiawa. In upper Pauoa, Oahu, the perpendicular rocks near the falls were covered with the dead fronds of this fern.

July 1 (2479).

ASPLENIUM L. Sp. Pl. 1078. 1753.

Asplenium diplazioides H. & A. Bot. Beechy Voy. 107. 1832.

Diplazium arnotti BRACK. Bot. U. S. Expl. Exped. **16**: 144. 1854.
Asplenium arnotti BAKER, Syn. Fil. Ed. 2, 240. 1874.

In wet woods, above Manoa, Oahu, at 2000 feet elevation, just below the edge of the plateau.
November 5 (2900).

Asplenium aspidioides SPRENG. Syst. Veg. **4**: 90. 1828.

Very common in upper Pauoa, and on the lower slopes of Konahuanui, Oahu, at elevations of 1500–2500 feet.
April to November (2073).

Asplenium contiguum KAULF. Enum. Fil. 172. 1824.

On a Kukui tree on Tantalus, and on the ground above Manoa, Oahu, at 2000 feet elevation.
April (2055, 2115).

Asplenium cuneatum LAM. Encycl. **2**: 309. 1786.

In rather dry woods, on Kaholuamanoa, above Waimea, Kauai, at 4000 feet, growing on the ground.
October (2865).

Asplenium deparioides BRACK. Bot. U. S. Expl. Exped. **16**: 172. 1854.

Along the left bank of the Wahiawa, Kauai, just below the second fall.
July 25 (2603).

Asplenium deparioides BRACK. var.

A much smaller plant than *A. deparioides*, with shorter pinnae and less falcate segments; found in wet woods near the head of the Wahiawa, at about 3000 feet elevation.
August 21 (2760).

Asplenium erectum BORY. in Willd. Sp. Pl. **5**: 328. 1810.

Along the banks of a stream shaded by Kukui trees, below the tabular summit above Waimea, Kauai, at about 2500 feet elevation.
October 1 (2845).

Asplenium erectum var. **subbipinnatum** Hillebr. Fl. Haw. Is. 590. 1888.

Not uncommon in the woods of Kaholuamano, above Waimea, Kauai, at 4000 feet. A delicate fern, with slender fronds, usually about eight inches in length.

September (2764).

Asplenium furcatum Thunb. Prodr. Fl. Jap. 172. 1784.

Growing on dry, exposed rocks, below the plateau of Kaholuamano, above Waimea, Kauai, at 3000 feet elevation.

October (2872).

Asplenium horridum Kaulf. Enum. Fil. 173. 1824.

Occasional in dry woods on Kaholuamano above Waimea, Kauai, at 4000 feet elevation. Apparently a local fern, as but few plants are ever found in any one locality. It was also noticed in upper Pauoa.

October (2853).

Asplenium horridum Kaulf. var.

Differs from the preceding in the nearly smooth, bluish rachis and pinnae, the segments being larger, more deeply and less obliquely cut. In damp woods between the Wahiawa and Hanapepe rivers, Kauai. Not uncommon at one place.

July (2588).

Asplenium lucidum Forst. Prodr. 427. 1789.

Referred by Baker to *A. obtusatum*, but quite distinct. Collected on the left bank of the Wahiawa, Kauai, just below the second fall.

July (2692).

Asplenium monanthemum Swz. Syn. Fil. 80. 1806.

Asplenium monanthes L. Mant. 130. 1771.

A rather common fern in the woods of Kaholuamano, above Waimea, Kauai, at 4000 feet, growing on the ground.

September (2771).

Asplenium nidus L. Sp. Pl. 1079. 1753.

This fern grows in various situations, and well deserves the name of "Bird's Nest Fern," the space enclosed by the bases of the fronds resembling a bird's nest. On the island of Oahu it was found growing on trees, on Tantalus and also above Manoa, while in Waialae, fine large plants grow on a shaded

ledge of rocks. In Hanapepe valley, Kauai, it occurs on rocks, on open exposed slopes.

April to August (2056).

Asplenium normale DON. Prodr. Fil. Nep. 7. 1825.

In damp woods, lower slopes of Konahuanui, and Kalihi, Oahu, on the ground. Usually proliferous.

April (2218).

Asplenium obliquum FORST. Prodr. 429. 1786.

On cliffs and in wet woods along the Hanapepe river, Kauai. Baker unites this with *A. obtusatum.*

July (2486).

Asplenium obtusatum FORST. Prodr. 430. 1786.

Growing under bushes at 1350 feet elevation, on the steep slope on the Konahuanui side of the Pali, Oahu.

May 24 (2361).

Asplenium resectum SM. Icones Ined. *pl. 72;* SWZ. Syn. Fil. 80. 1806.

Below the plateau of Kaholuamano, Kauai, at about 2500 feet elevation, along the bed of a stream, gregarious. It also occurs below the edge of the plateau above Manoa and Pauoa, Oahu, in moist ground. Hillebrand records it as "common on trees and rocks," but I have not seen it except at the places mentioned above, and only on ground where there is considerable moisture.

October (2844).

Asplenium rhizophyllum KUNZE, Linnaea, **9**: 71. 1852.

Growing under larger ferns and bushes, on Tantalus, Oahu, above Honolulu, at 2000 feet elevation.

April (2117).

Asplenium scandicinum (WILLD.) PRESL. Tent. Pter. 98. 1836.

Aspidium scandicinum WILLD. Sp. Pl. **5**: 285. 1810.

On the ground in wet woods along the Wahiawa, Kauai, at about 2500 feet. Baker unites this with *A. aspidioides*, but the Island forms, at least, are very distinct plants. Hillebrand, instead of using his own judgment and field observations, follows Baker.

July (2623).

Asplenium sphenotomum HILLEBR. Fl. Haw. Is. 599. 1888.

In the woods of Kaholuamano, above Waimea, Kauai, at 4000 feet elevation, growing on the ground and on trees. A handsome fern, more plentiful in deep wet woods, than in the dry outer forest.

September (2765).

Asplenium vexans UNDERW. n. sp.

Rootstock stout, ascending or erect, covered with the thickly placed bases of the fallen petioles; petioles about 25 cm. long, with a dense tuft of dark brown scales at the base, smooth and pale brown above; leaves membranous, triangnlar-ovate, about 30 cm. long, 20 cm. wide at the base, triquadripinnatifid; pinnae about 14 pairs, the lower widest in the middle, the upper wider at base, all provided with a winged rachis; pinnules 2 to 3 cm. long, oblong-lanceolate, cut almost to the base into decurrent segments which in the larger pinnules are cut into 3 or 4 acute divisions, or in the smaller are entire or 2 to 3 toothed at the apex; veins forked, single in each tooth; sori 4 to 6 to each pinnule mostly confined to its upper half.

On the ground, on Tantalus, and above Pauoa and Manoa, Oahu, in damp woods under larger ferns.

Allied to *A. cicutarium* in texture and habit. It bears a close resemblance to *A. scandicinum*, and was probably confounded with that plant by Hillebrand.

April to November (2058).

CIBOTIUM KAULF. Berl. Jahrb. der Ph. 1820.

Cibotium Chamissoi KAULF. Enum. Fil. 230, *pl. 1, f. 14.* 1824.

In moist ground, beneath the edge of the plateau above Manoa, Oahu, at 2000 feet elevation.

November (2898).

Cibotium menziesii HOOK. Sp. Fil. **1**: 84. *Pl. 29 c.* 1846.

Common in damp woods along the Wahiawa, Kauai, at 2000 to 2500 feet elevation, and on Kahaluamano above Waimea. This species is easily distinguished from the others by the long brown hair on the stipes, and to an observant person the whole plant presents a different appearance from any of the other species.

August (2693).

Cibotium pruinatum METT. in Kuhn. Linnaea, **36**:150. 1869.

Along streams in wet woods, near the Wahiawa, Kauai, and on Kaholuamano (2818). The three forms referred to this species differ materially from each other, and also from the brief description which this plant has received. They are all distinctly wooly-hairy beneath. No. 2600 is nearest to *C. glaucum*, but differs in its hairy under surface. It is necessary to study these forms in their native woods, before the species can be well understood.

August to October (2590, 2600, 2818).

DAVALLIA SMITH, Mem. Acad. Turin. **5**:414, *pl. 9.* 1793.

Davallia speluncae (L.) BAKER. Syn. Fil. Ed. 2, 100. 1874.

Common in upper Pauoa, Oahu, at 1500 feet elevation, and in gulches on the ridge west of the Hanapepe river, Kauai, at 3000 feet. Also above Waimea, Kauai. Hillebrand seems to have been rather unfamiliar with the vegetation of such an easily accessible place as the heights of Pauoa, for he says: "Rare, found by me on the Waianae mountains, Oahu, and near Hilo, Hawaii, only."

April to July (2072 Oahu, 2650 Kauai).

Davallia strigosa SWARTZ, Syn. Fil. 98., 1806.

Said to be a very common fern on all of the islands of the Hawaiian group. In Pauoa, Oahu, it was found in sheltered places on grassy slopos, under bushes (2012), and on the outskirts of the woods at about 1500 feet elevation, in much damper situations (2327). On Kauai, a less hairy form was found in the valley of the main tributary of the Hanapepe river, growing in shade under trees (2480).

Davallia strigosa SWARTZ, var.

In open places near the edge of the forest above Waimea, Kauai, growing in great profusion, is a form which differs from the above by having a narrower leaf, narrower and more veiny pinnae, pinnules and segments.

September 10 (2803).

Davallia tenuifolia SWARTZ, Schrader's Journ. **2**:88. 1800.

This plant is very common in the lower woods where the timber is thin, and seems to prefer drier situations than many of the other ferns. Collected in Pauoa, Oahu, and on Kaholuamano, Kauai.

April to October (2328).

DEPARIA H. & G. Icon. Fil. *pl. 154*. 1828.

Deparia prolifera (KAULF.) HOOK. Sp. Fil. **1**: 85. 1846.

Dicksonia prolifera KAULF. Enum. Fil. 225. 1824.

In wet woods at an elevation of about 3000 feet, near the head of the Wahiawa, this fern was occasionally found. Hillebrand united this species with *Asplenium deparioides*, but apparently without valid reason for the two species are easily distinguished.

August 21 (2740).

Deparia triangularis UNDERW. n. sp.

Rootstock short and thick; petioles 35 cm. long, stout, naked except for a few ferruginous scales near the base, brownish below, lighter above; leaves elongate-triangular, half a metre or more long, bipinnatifid or nearly bipinnate below; lower pinnae 20 cm. or more long with somewhat irregular falcate segments 4 to 5 cm. long, 1 cm. or more wide, with irregular jagged margins; upper pinnae narrower, lanceolate, cut nearly to the midrib into falcate segments 1.5 cm. long; sori about 8 to each of the upper segments, more numerous below.

On the ground, Oahu, (2057).

A peculiar species with very irregular leaves, distinct from *D. prolifera*, which is the only other species of the genus found in the Hawaiian islands.

DOODIA R. BR. Prodr. Fl. Nov. Holl. 151. 1810.

Doodia media R. BR. Prodr. Fl. Nov. Holl. 151. 1810.

Collected at an elevation of 2000 feet on the left bank of the Wahiawa, Kauai, below the second fall, where it was growing on open banks. Later it was observed at higher elevations on the ridges west of the Hanapepe river. The species is also found in Australia and New Zealand.

July 22 (2601).

DRYOPTERIS ADANS. Fam. Pl. **2**: 20. 1763.

[**Aspidium** SW. Schrader's Journ. Bot. **2**: 20. 1800.]

Dryopteris coniifolia (WALL.) UNDERW.

Aspidium coniifolium WALL. Cat. n. 341. 1828.

Growing on the edge of a stream, above Waimea, Kauai, at 4000 feet elevation. Apparently rare, as only a few plants were found.

September 14 (2817).

Dryopteris caryotidea (WALL.) UNDERW.

Aspidium caryotideum WALL. Cat. n. 376. 1828.

This species was first detected at an elevation of about 3000 feet, on the side of a gulch on the ridge west of the Hanapepe river, Kauai. Later it was noted in a deep valley above Waimea, at about 2000 feet elevation. It prefers rather open situations, and does not appear to be plentiful. It differs, according to Hillebrand, from Asiatic plants of this species.
July 11 (2544).

Dryopteris cicutaria (SWARTZ) KUNTZE, Rev. Gen. Pl. 812. 1891.

Aspidium cicutarium SWARTZ, Schrader's Journ. **2**: 279. 1803.

In a deep gulch at the foot of the tabular summit, above Waimea, Kauai, at about 2000 feet elevation. It was also noticed in upper Pauoa and Kalihi valleys, Oahu, near streams.
October 1 (2842).

Dryopteris cyatheoides (KAULF.) KUNTZE, Rev. Gen. Pl. 812. 1891.

Aspidium cyatheoides KAULF. Enum. Fil. 234. 1824.

Common, growing on the ground, in open places in the lower forest Oahu (1991). On Kaholuamano, Kauai, growing along a stream in the woods, a large form was collected, with wider and much more closely imbricate pinnae (2857).

Dryopteris filix-mas (L.) SCHOTT. Gen. Fil. 1834.

Polypodium filix-mas L. Sp. Pl. 1090. 1753.

Common on Kauai, in damp woods, at elevations of 2000 to 4000 feet. Collected first on the ridge between the Hanapepe and Wahiawa rivers (2587), and later on Kaholuamano (2746). The specimens referred to this species are quite different from the European or American forms.

Dryopteris filix-mas var. **parallelogramma** (KZE.) UNDERW.

Aspidium filix-mas var. *parallelogramma* KZE. Linnaea **13**: 140. 1857.

At an elevation of about 3000 feet, on a dry ridge, west of the Hanapepe river, Kauai. Compared with the ordinary forms of the male fern, this would certainly be a distinct species.
August 22 (2749).

Dryopteris latifrons (BRACK.) KUNTZE, Rev. Gen. Pl. 813. 1891.

Lastrea latifrons BRACK. Bot. U. S. Expl. Exped. **16**: 196. 1854.

At the base of a large rock, on the edge of the plateau above Manoa, Oahu, at an elevation of about 2000 feet. An endemic Hawaiian fern, recorded as occuring on all the islands, but not common.

October 30 (2899); probably from the type locality, "Oahu, Sandwich Islands; on the high mountains behind Honolulu."

Dryopteris parasitica (L) KUNTZE, Rev. Gen. Pl. 811. 1891.

Polypodium parasiticum L. Sp. Pl. 1090. 1753.
Nephrodium molle DESV. Mem. Soc. Linn. **6**: 258.

Common on Oahu, in open places, valleys, and slopes, barely reaching to the lower limit of the lower forest.

March 26 (2011).

Dryopteris nuda UNDERW. n. sp.

Rootstock short; petioles caespitose, 20 to 25 cm. long, naked throughout, brownish below, lighter above, extending into a stramineous rachis; leaves triangular-ovate, 25 to 30 cm. long, tripinnatifid; lowest pinnae much the largest, 13 cm. long by about 10 cm. or more wide at the base, unequally triangular, the lower pinnule much larger and more divided; upper pinnae varying from broad triangular to lanceolate, always widest at base, the uppermost simple; ultimate segments with short, somewhat distant, sharp serrations; veins pinnate, the branches obscurely forked; sori small, marginal, one at the lower side of each tooth or segment; indusia withering persistent.

Resembling somewhat small forms of our common *D. spinulosa*, but a much more rigid plant with less pronounced serrations and different habit. The rachises throughout have occasional narrow scale-like hairs of a reddish color.

This plant was common on Kauai in rather dry woods. It was first collected at an elevation of 2000 feet, on the ridges between the Hanapepe and Wahiawa rivers, later on the ridge west of the Hanapepe, at 2000 feet, and also at 4000 feet above Waimea.

August to October (2750).

Dryopteris squamigera (H. & A.) KUNTZE, Rev. Gen. Pl. 813. 1891.

Nephrodium squamigerum H. & A. Bot. Beechey, 106. 1833.

On the face of a perpendicular rock in a gulch above Waimea, Kauai, at an elevation of 2000 feet, this species was plentiful,

but was not seen at at any other place. Being exposed directly to the afternoon sun, many of the plants were withered. The species is said to be rare on the Islands, but is also recorded from the Society and Viti islands.

October 1 (2841).

Dryopteris truncata (GAUD.) KUNTZE, Rev. Gen. Pl. 814. 1891.

Aspidium truncatum GAUD. Bot. Voy. Uranie 333, *pl. 10.* 1830.

This is a rather common fern, growing in damp situations at medium elevations. First collected in Kalihi valley, Oahu (2334), and later above Waimea and along the Hanapepe river, Kauai (2843).

Dryopteris unita (L.) KUNTZE, Rev. Gen. Pl. 811. 1891.

Polypodium unitum L. Sp. Pl. Ed. 2, 1548. 1763.

Common along streams and wet places, below the forest. The highest place where it was noticed, was on the grassy slope at the head of Pauoa, at about 1000 feet elevation. The plant is stiff and erect, with ascending pinnae.

July to October (2594); original locality, "in Indiis."

GYMNOGRAMMA DESV. Berl. Mag. **5**: 304. 1811.

Gymnogramma javanica BLUME, Fil. Jav. 95, *pl. 41.* 1830.

Gymnogramma pilosum BRACK. Bot. U. S. Expl. Exped. **16**: 22. 1854.

Collected at elevations of from 3000 to 4000 feet, on Kauai. On the ridge west of the Hanapepe river it was found growing in damp woods among other ferns, but not plentifully. Above Waimea it was more plentiful in deep woods along streams, and was also of a much more luxuriant growth.

July to October (2637).

Gymnogramma sadlerioides UNDERW. n. sp. *(Plate XLIII.)*

Rootstock short, rather stout, nearly erect; petioles 12 to 15 cm. long, purplish brown, sparingly clothed with long, slender, pale brown scales; leaves pinnatifid or nearly bipinnate, lanceolate, 28 to 30 cm. long, about 4 cm. wide; pinnae with 3 to 6 pairs of ovate pinnules, the lower smaller, horizontal or slightly curved upwards; pinnules 5 to 6 mm. long, blunt, entire, the lateral margins slightly recurved; veins free, producing a branch on either side near the base of the pinnule, each of which bears a short linear sorus which stands on the pinnule half way from the main vein to the margin; sporangia short stalked, 12 to 15 in a sorus.

An unique species, entirely unlike any others in this multi-typical genus, which should properly be divided into a number of genera, as is the practice of almost all pteridologists outside of Kew. If it does not form a section by itself, it will come nearest in character to § *Leptogramme*, though very different from any described form of that section. It is named from the resemblance to *Sadleria squarrosa* in the cutting of the leaf.

Hanging from a rock wall, on Kaholuamano above Waimea, Kauai (2863).

HYPOLEPIS BERNH. Schrader's Neues Journ. **1**: 34. 1806.

Hypolepis tenuifolia (FORST.) BERNH. Schrader's Neues Journ. **1**: 34. 1806.

Lonchites tenuifolia FORST. Prodr. n. 424. 1786.

This species is not uncommon in deep forests, at an elevation of 4000 feet, above Waimea, Kauai.

August 31 (2778).

NEPHROLEPIS SCHOTT. Gen. Fil. *pl. 3.* 1834.

Nephrolepis acuta (SCHK.) PRESL. Lent. Pterid. 79. 1836.

Aspidium acutum SCHK. Fil. 32, *pl. 31.*

Very common on trees and on the ground in the lower forest, and extending up into the middle forest zone. Specimens were collected in Nuuanu valley, Oahu, at an elevation of 1000 feet.

March 23 (1987).

Nephrolepis exaltata (L.) SCHOTT. Gen. Fil. 1834.

Polypodium exaltatum L. Sp. Pl. Ed. 2, 1548. 1763.

While *N. acuta* is confined to low and medium elevations, this species replaces it at high elevations. On Kauai, where the highest point is somewhat under 5000 feet, *N. exaltata* is plentiful at elevations of from 3000–4000 feet.

October 11 (2873); original locality, "in America."

PHEGOPTERIS FEÉ. Gen. Fil. 242. 1850–52.

Phegopteris honolulensis (HOOK.) HELLER.

Polypodium honolulense HOOK. Sp. Fil. **4**: 288. 1862.

Polypodium hillebrandii HOOK. Sp. Fil. **4**: 254. 1862, not *P. hillebrandii* HOOK. l. c. 228.

Phegopteris hillebrandii HILLEBR. Fl. Haw. Is. 566. 1888.

At an elevation of 4000 feet, above Waimea, Kauai, this species is rather common along streams, somewhat resembling *Asplenium aspidioides* at a casual glance.

September 14 (2814).

Phegopteris polycarpa (H. & A.) HILLEBR. Fl. Haw. Is. 560. 1888.

Polypodium polycarpum H. & A. Bot. Beechy, 104. 1832.
Stenogramme Sandwicensis BRACK. Bot. U. S. Expl. Exped. **16**: 26, *pl. 4.* 1854.
Phegopteris microdendron D. C. EATON in Mann. Proc. Am. Acad. **7**: 218. 1867.
Polypodium stenogramnioides BAKER. Synop. Fil. 317.

This handsome species was collected at an elevation of 4000 feet above Waimea, Kauai, where the long fronds grew drooping over the edge of a stream in the forest. It is probably Hillebrand's var. *Kauaiensis*, which was collected by Knudsen on Halemanu, which is separated from Kaholuamano, where my specimens grew, by the deep gorge of the west branch of the Waimea river. Hooker and Arnott's specimen must have been collected on Oahu, as the Beechy expedition collected only on Oahu and Nihaui, and the latter island is too low to afford favorable situations for the growth of this fern. It was observed high up on the slopes of Konahuanui, Oahu. It is an endemic Hawaiian fern, and said by Hillebrand to be "not uncommon."

September 30 (2839).

Phegopteris punctata (THUNB.) HILLEBR. Fl. Haw. Is. 562. 1888.

Polypodium punctatum THUNB. Fl. Jap. 337. 1784.

A fern common in the woods on the ridge between the Wahiawa and Hanapepe rivers, Kauai, and near the former stream. Not reported from Kauai by Hillebrand.

July 18 (2587).

Phegopteris spinulosa HILLEBR. Fl. Haw. Is. 566. 1888.

A tall fern, found growing among a tangle of other large ferns on a stream bank at an elevation of 4000 feet above Waimea, Kauai. Very little of it was found, but this is probably due to the fact that it resembles rather closely several other more common species of the same genus, and hence was usually overlooked. A peculiar Hawaiian fern. Hillebrand's types came from Maui and Hawaii.

October 11 (2874).

Phegopteris unidentata (H. & A.) Mann. Proc. Am. Acad. 7:218. 1867.

Polypodium unidentatum H. & A. Bot. Beechy, 105. 1832.

Collected at an elevation of 4000 feet above Waimea, Kauai, along a stream in the woods. It is an endemic Hawaiian fern, said to grow on all the islands of the group, at elevations of from 2000 to 4000 feet.

September 30 (2838).

POLYPODIUM L. Sp. Pl. 1082. 1753.

Polypodium abietinum D. C. Eaton, in Mann. Proc. Am. Acad. 7:219. 1867.

On moss covered trees, at 3000 feet elevation, in wet woods, near the bog at the head of the Wahiawa river, Kauai. Hillebrand refers this species to *P. tamariscinum*, but it is certainly a very distinct species. It is perhaps common in favorable situations, but owing to its small size, and habit of growing on tree limbs among moss, may easily be overlooked. It has been found only on the Hawaiian group.

August 21 (2732).

Polypodium hawaiiense Underw. n. sp.

Rootstock wide creeping, clothed when young with dense cinnamon-colored scales; petioles rising at intervals of 2 to 3 cm., stout, olive-brown, 7 to 8 cm. long, smooth; leaves dark green, 18 to 20 cm. long, with about 14 pairs of horizontal divisions, 3 to 4.5 cm. long, 1.5 cm. wide, crenate, blunt and rounded at the ends, crowded at the base so that the margins often overlap, not at all decurrent; veins about four times forked; sori very large, borne on the primary branch of the veins approximate to the midrib.

This species also belongs to the same group as *P. pellucidum* and differs from that fern in texture, in the form of the pinnae which are never decurrent, broader, more blunt and approximate; also in the venation and in the position and size of the sori. Mr. Heller informs me that there were no intermediate forms between this species and *P. pellucidum*, from which it seems to be clearly distinct.

On trees and stumps in damp woods, on Kauai, at elevations of 3500 to 4000 feet. Collected first on the ridge west of the Hanapepe river, and later on Kaholuamano, above Waimea.

August to October (2634).

Polypodium helleri UNDERW. n. sp.

Rootstock moderately slender, creeping, clothed especially when young with slender cinnamon-colored scales; petioles rising at intervals of about 1.5 cm., stramineous, 10 to 15 cm. long, distinctly pubescent as are the rachises; leaves 20 to 35 cm. long, 10 to 12 cm. wide, ovate-lanceolate, parted into about 30 pairs of narrow linear divisions, which are 5 to 7 cm. long, 7 to 10 mm. wide, mostly narrower toward the base and separated by a broad sinus, crenate especially toward the end; veins with about three forks, occasionally uniting, mostly free; sori on the primary branch of the vein, light colored, small.

A very distinct species belonging to the same group as *P. pellucidum*, but differs from that species in its thinner texture, with sori only half as large, pinnae longer, narrower, more numerous and in every way different in form and habit.

On tree trunks and rocks just below the second fall of the Wahiawa river, Kauai, at an elevation of 2000 feet.

July 22 (2602).

Polypodium hookeri BRACK. Bot. U. S. Expl. Exped. **16**: 4. 1856.

This species is not uncommon on wet, moss-covered trees, from an elevation of 2,000 feet to the summit of Konahuanui, Oahu. From its habit it may be easily overlooked.

May to November (2245).

Polypodium lineare THUNB. Fl. Jap. 335, *pl. 19.* 1784.

A common fern, ranging from the lower forests to 3500 feet on Kauai. On Oahu it was found growing on exposed rocks (2005, 2031), and on trees, especially on *Acacia Koa* (2076). On Kauai, a large broad form, with undulate margins (2533), occurred on trees, on the ridges west of the Hanapepe river.

Polypodium pellucidum KAULF. Enum. Fil. 101. 1824.

Collected only in upper Pauoa, Oahu. On Kukui trees.

March (2054).

Polypodium pseudo-grammitis GAUD. Bot. Voy. Uranie, 345. 1830.

A very common fern, growing on rotten logs, stumps, and tree trunks, at elevations of 2000 to 4000 feet. Collected on both Oahu and Kauai.

April to October (2215).

Polypodium samoense BAKER, Syn. Fil. Ed. 2, 321. 1874.

This species was found only in wet woods, near the bog at the head of the Wahiawa river, growing on moss-covered limbs. In the Hawaiian group, it has been reported only from the island of Kauai.

August 12 (2708).

Polypodium sarmentosum BRACK. Bot. U. S. Expl. Exped. **16**:8, *pl. 2, f. 3.* 1854.

Quite common on trees and bushes from an elevation of 2000 feet, to the summit of Konahuanui, Oahu. A Hawaiian fern, common on all of the islands.

May to October (2353)

Polypodium serrulatum (SWARTZ) METT. Ueber Einige Farngatt l. Polypodium, 32. 1857.

Asplenium serrulatum SWARTZ, Fl. Ind. Occ. 1607. 1806.
Xiphopteris serrulata KAULF. Enum. Fil. 85. 1824.

This handsome little species was collected at an elevation of little more than 3000 feet, near the summit of Konahuanui, Oahu. It was also seen in similar situations on Kauai. It grows only on wet, moss-covered trees.

November 2 (2905).

Polypodium spectrum KAULF. Enum. Fil. 94. 1824.

This singular fern is common in the lower woods, where its long vine-like rootstalks creep and twine over trees and rocks. The form from Oahu (2118), has blunt lobes, while in specimens from near the Hanapepe falls, Kauai (2438), there are five sharp-pointed lobes. It is reported as growing also in Sumatra.

Polypodium tamariscinum KAULF. Enum. Fil. 117. 1824.

Common on trees and on the ground, but found at its best on the wet summit of Konahuanui (2214). At 4000 feet elevation, above Waimea, Kauai, was found a fine form (2855), sometimes referred to a distinct species (*Adenophorus tripinnatifidus* GAUD.).

PTERIS L. Sp. Pl. 1073. 1753.

Pteris aquilina L. Sp. Pl. 1075. 1753.

This species of world-wide diffusion, was common on grassy slopes below the forest on Kauai.

June 22 (2416).

Pteris decipiens Hook. Sp. Fil. **2**: 209. 1858.

The first specimens of this fern were found at 1200 feet, growing in crevices of moist rocks, at the Pali, Oahu, which is probably the original station, as the type came from Oahu. Later it was noticed at the foot of Hanapepe falls, Kauai, and very handsome specimens were obtained in a ravine above Waimea, where it grew on a rock shaded by Kukui trees. It is an endemic species.

March to October (1990).

Pteris decora (Brack.) Hook. Sp. Fil. **2**: 210. 1858.

Dryopteris decora Brack. Bot. U. S. Expl. Exped. **16**: 103, *pl. 13, f. 1.* 1854.

On exposed rocks below the forests, on the ridge west of the Hanapepe river, and above Waimea, Kauai, both stations at elevations of about 2000 feet. Professor Underwood says, "It is doubtful if this species can be maintained as a *Pteris*." I certainly had no idea that it was such when the specimens were collected. It has been found only on the Hawaiian group.

Pteris excelsa Gaud. Bot. Voy. Uranie, 388. 1830.

A fine large fern, which grows in company with *Davallia speluncae* and *Asplenium aspidioides*, in damp gulches at elevations of about 3000 feet, on the island of Kauai.

July 31 (2649).

Pteris irregularis Kaulf. Enum. Fil. 189. 1824.

Collected in dry open places on the margin of the woods above Waimea, Kauai, at elevations of 3000 to 4000 feet. A handsome species growing in clumps.

August 31 (2782).

Pteris regularis E. Bailey, Hawaiian Ferns, 26. 1883.

A species of apparently local distribution, found in wet gulches along streams. It was collected in Kalihi valley, Oahu, at about 1200 feet elevation, and was also seen in Pauoa and from the island of Kauai. Professor Underwood says: "A species well characterized in Mr. Bailey's too modest pamphlet."

May 20 (2335).

SADLERIA Kaulf. Enum. Fil. 161. 1824.

Sadleria pallida H. & A. Bot. Beechy, 75. 1832.

On the edge of a hill, in a dry and exposed place, at 4000 feet, above Waimea, Kauai. A small species with no appreciable trunk.

October 7 (2866).

Sadleria souleytiana (Gaud.) Hillebr. Fl. Haw. Is. 581. 1888.

Blecchnum souleytiana Gaud. Bot. Voy. Bonite *pl. 2* and *134* without description.

A tree fern, with short trunk, and stout fleshy leaves, growing at an elevation of 4000 feet above Waimea, Kauai, in deep wet woods. The auricles at the base of the stipes are much more prominent in this fern than they are in *Marattia*, and are quite palatable.

September 11 (2807).

Sadleria polystichoides (Brack.) Heller.

Blechnum polystichoides Brack. Bot. U. S. Expl. Exped. **16**: 134. 1854.

Blechnum squarrosum Gaud. Bot. Voy. Bon. *pl. 2, f. 1-6*, without description.

Sadleria squarrosa Mann. Proc. Am. Acad. **7**: 213. 1867.

Collected on the slope of Waiolani, at an elevation of about 2000 feet above "Hillebrand's Gulch." It is a small fern, the smallest of this genus on the islands, and can hadly be called a tree fern. Mann says: "I have seen specimens not over a foot high including caudex and all, in luxuriant vegetation."

June 10 (2392).

VITTARIA Sm. Mem. Acad. Turin. 5:413, *pl. 9.* 1793.

Vittaria elongata Swartz. Syn. Fil. 109. 1806.

Growing on trees, usually on the Kukui, at medium elevations, and common on both Oahu and Kauai (2054). On Kauai, on the ridge above Gay & Robinson's house, occurred the form known as *V. zosteraefolia* (2532), which has the lower side of the groove shorter, thus plainly showing the fructification.

GLEICHENIACEAE.

GLEICHENIA Smith. Mem. Acad. Turin. 5: 419, *pl. 9.* 1793.

Gleichenia dichotoma (Willd.) Hook. Sp. Fil. 1: 12. 1846.

Mertensia dichotoma Willd. Act. Holm. 167. 1804.

This species is common in dry, open situations on the edge of the woods, and also at considerable elevations, in thick wet woods. It is called "Stag Horn." In many places it forms almost impassible jungles, the long, vine-like branches interlacing with one another and also climbing over bushes.

August 23 (2761).

Gleichenia longissima Blume, Enum. 250. 1830.

Gn the ridge opposite Gay & Robinson's valley house, at an elevation of 2500 feet. Also at a higher elevation on the ridge west of the Hanapepe river, and at 4000 feet above Waimea, Kauai, where it was growing along a stream bank. A handsome species, more confined to the ground than *G. dichotoma*, and much less inclined to spread.

July 23 (2613).

Gleichenia owhyhensis Hook. Sp. Fil. 1: 9. 1846.

Only a few specimens of this species were picked up near the summit of Konahuanui, Oahu, growing where the stunted trees are covered with dense growths of dripping mosses and hepatics. Here it replaces *G. dichotoma*, which it somewhat resembles, and which is abundant on the lower and drier slopes of the same mountain. There is no authority for changing this name to *hawaiiensis*, as some have done. The species is endemic to the Hawaiian group.

SCHIZAEACEAE.

SCHIZAEA Smith, Mem. Acad. Turin. 5: 419. 1793.

Schizaea robusta Baker, Syn. Fil. Ed. 2, 429. 1874.

The first specimens of this plant were collected at an elevation of perhaps 2500 feet, on Konahuanui, Oahu, on a little level spot in clay formation. The plants were small and stunted. It was also found on the opposite side of Nuuanu valley, on the slope of Waiolani, at the same elevation. Near the Wahiawa bog on Kauai, large and beautiful specimens were

obtained. Diligent search in situations favorable to its growth, would probably prove it to be much less rare than it is supposed to be, as it is a plant easily passed by.

May to August (2246).

HYMENOPHYLLACEAE.

HYMENOPHYLLUM SMITH, Mem. Acad. Turin. 5:418. 1793.

Hymenophyllum lanceolatum H. & A. Bot. Beechy, 109. 1832.

On trees on Konahuanui, Oahu, especially toward the summit (2229, 2256). On Kauai, it was collected on trees, near the Wahiawa bog (2750), at 3000 feet elevation.

Hymenophyllum obtusum H. & A. Bot. Beechy, 109. 1832.

A small fern, usually with brownish fronds. It grows in moss-like tufts on tree trunks. Collected at 2000 feet elevation, above Manoa, Oahu. The type was collected by Lay and Coolie, on Oahu.

November 5 (2910).

Hymenophyllum recurvum GAUD. Bot. Voy. Uranie, 576. 1830.

On trees and rotten logs. Common at medium elevations on Oahu and Kauai. A handsome plant, light green in color.

July 25 (2620).

TRICHOMANES L. Sp. Pl. 1097. 1753.

Trichomanes apiifolium PRESL. Hymenophyllaceae, 44. 1843.

A few clumps of this species were found at about 2500 feet elevation, on Konahuanui, above the Nuuanu valley gulch. It grows on the ground.

April 22 (2179).

Trichomanes humile FORST. Prodr. n. 464. 1786.

On the left bank of the Hanapepe river, above the junction, and near the falls, is a large rock shaded by a thick growth of "Ohia" trees (*Eugenia malaccensis*), on which this small fern grows in abundance. It was not observed at any other station.

July 12 (2556).

Trichomanes meifolium Bory, in Willd. Sp. Pl. **5**:508. 1810.

At 4000 feet above Waimea, Kauai, there was an abundance of this fern, growing on perpendicular rocks along the stream, just below Gay & Robinson's Kaholuamano house. However, very few good specimens could be found, as nearly all of the fronds were withered.

September 14 (2816).

Trichomanes radicans Swartz, Fl. Ind. Occ. 1736. 1806.

A very common fern on both Oahu and Kauai, where it was found climbing over tree trunks and rocks in the lower and middle woods.

April to October (2119).

Trichomanes rigidum Swartz, Fl. Ind. Occ. 1738. 1806.

A few plants were collected in wet woods, near the head of the Wahiawa river, Kauai, at an elevation of 3000 feet.

August 21 (2741).

MARATTIACEAE.

MARATTIA Smith, Mem. Acad. Turin. 5:419. 1793.

Marattia douglasii Baker, Syn. Fil. Ed. 2, 441. 1874.

This is a plant of high elevations, at least on Kauai and Oahu. On Kauai, it was collected at 4000 feet, along the stream near Gay & Robinson's Kaholuamano house, above Waimea On Oahu, it was seen only near the summit of Konahuanui. It seems to occur only in places where there is a great deal of moisture, and may be found at much lower elevations on the windward sides of the islands.

August 30 (2770).

LYCOPODIALES.

LYCOPODIACEAE.

LYCOPODIUM L. Sp. Pl. 1100. 1753.

Lycopodium cernuum L. Sp. Pl. 1103. 1753.

Very common in open places on the outskirts of the forest, and also at considerable elevations on some of the ridges. Called "rat's foot" by the natives. Specimens were collected near the Wahiawa river, Kauai, at about 2000 feet elevation.

July 22 (2596); original locality, "in Indiis."

Lycopodium phyllanthum H. & A. Bot. Beechey, 103. 1832.

A species found only on the Hawaiian Islands, occurring at intervals at medium elevations in the forests. Pendant from moss grown trees, at 2500 feet and more, on both Kauai and Oahu.

April to October (2192).

Lycopodium serratum THUNB. Fl. Jap. 341, *pl. 38.* 1784.

On the ridge west of the Hanapepe river, Kauai, at an elevation of about 3000 feet, this species grew abundantly, at one place, on the ground beneath trees (2687). In wet woods near the Wahiawa bog, occasional plants were picked up. On Oahu, it was found growing on the ground under bushes (2904), at an elevation of about 2700 feet, on Konahuanui.

Lycopodium verticillatum L. f. Suppl. 448. 1781.

Only two or three plants of this species were found, at 2500 feet elevation, on Konahuanui, Oahu, growing on mossy trees. It is apparently rare.

PSILOTUM SWARTZ, Syn. Fil. 187. 1806.

Psilotum complanatum SWARTZ, Syn. Fil. 414. 1806.

Not nearly so common as *P. nudum*, and found only on trees. It was collected on both Oahu and Kauai.

April to November (2216).

Psilotum nudum (L.) GRIESB.

Lycopodium nudum L. Sp. Pl. 1100. 1753.
Psilotum triquetrum SWARTZ, Syn. Fil. 414. 1806.

A very common plant, growing on slopes below the forest, and at higher elevations on trees. Collected on both Oahu and Kauai.

March to September (1989); original locality, "in Indiis."

SELAGINELLA BEAUV. Prodr. Aetheog, 101. 1805.

Selaginella arbuscula (KAULF.) SPRING. Monog. Fam. Lycop. 2: 183. 1848.

Lycopodium arbuscula KAULF. Enum. Fil. 19. 1824.

On moist rocks, at 1200 feet elevation, at the Nuuanu Pali, Oahu. The plants were small and not very plentiful.

March 23 (1993).

Selaginella flabellata (L.) SPRING. Monog. Fam. Lycop. 2:174. 1848.

Lycopodium flabellatum L. Sp. Pl. 1105. 1753.

On the ground; a rather common species, colleted at 2500 feet and more on Konahuanui, Oahu (2180), and at 3000 feet on the ridge west of the Hanapepe river, Kauai (2499). Original locality, "America calidiore."

Lycopodium menziesii H. & G. Enum. Fil. No. 131.

Collected at about 500 feet elevation in Pauoa valley, Oahu, where it grew on rocks. Among the specimens from this place were some of an elongate form (2009). On Kauai, it was collected on the stones at the foot of Hanapepe falls, where it was kept continually moist by the spray from the falls (2558).

NAIADACEAE.

POTAMOGETON L. Sp. Pl. 126. 1753.

Potamogeton foliosus RAF. Med. Rep. (II) 5: 354. 1808.

Potamogeton pauciflorus PURSH, Fl. Am. Sept. 121. 1814.

In lower Pauoa, Oahu, at about 50 feet elevation, in taro patches (2387), apparently introduced. On Kauai it was collected in a pool along the Hanapepe river, near the falls, at an elevation of about 700 feet, and in a similar situation at the second fall of the Wahiawa, elevation 2000 feet. It is certainly native at the Kauai station. This species has always been considered peculiar to North America, hence its occurrence in the Islands is of considerable interest.

Michaux, in *Flora Bor. Am. 1*: 102, doubtfully referred this species to *P. gramineum* L.

June 4 (2387); July 12 (2555); original locality, "in rivis affluente mari inundatis Carolinae inferioris."

GRAMINEAE.*

CALAMAGROSTIS ADANS. Fam. Pl. 2: 31. 1763.

Calamagrostis forsteri (R. & S.) STEUD. Nom. Bot. 250. 1841.

Agrostis forsteri R. & S. Syst. **2**: 359. 1817.

Collected in clay soil, at 4000 feet elevation, above Waimea, Kauai, growing in a small glade in the forest. The species is recorded from Molokai, Lanai, and Maui, by Hillebrand, under the name of *Deyeuxia forsteri.* Its occurrence at such a distance from the other stations is somewhat remarkable.

September (2779).

CAPRIOLA ADANS. Fam. Pl. 2: 31. 1763.

[**Cynodon** RICH.; PERS. Syn. **1**: 85. 1805.]

Capriola dactylon (L.) KUNTZE. Rev. Gen. Pl. 764. 1891.

Panicum dactylon L. Sp. Pl. 58. 1753.
Cynodon dactylon PERS. Syn. **1**: 85. 1805.

A common grass on all of the islands, in low ground near the sea. It was introduced about 1835. Collected at Capiolani Park, where it grew along the race track.

March 20 (1960); original locality, "in Europa australi."

CENCHRUS L. Sp. Pl. 1049. 1753.

Cenchrus echinatus L. Sp. Pl. 1050. 1753.

Common about Honolulu, in yards, waste places, and cultivated grounds. Collected at Capiolani Park, along the race track. It was introduced in 1867.

March 20 (1964).

CHLORIS SWARTZ, Prodr. 25. 1788.

Chloris radiata (L.) SWARTZ, Prodr. Veg. Ind. Occid. 26. 1788.

Agrostis radiata L. Amoen. Acad. **5**: *392*. 1759.

In dry ground, not far from the sea shore, on the islands of Oahu, Kauai, and Hawaii. Specimens were collected at Capiolani Park, near Honolulu.

March 20 (1963); original locality, Jamaica.

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* The determinations and citations by Mr. Geo. V. Nash.

CHRYSOPOGON TRIN. Fund. Agrost. 187. 1820.

Chrysopogon aciculatus (RETZ.) TRIN. Fund. Agrost. 188. 1820.

Andropogon aciculatus RETZ Obs. **5**: 22. 1779–91.

A common grass on open slopes below the forests, on both Oahu and Kauai. Collected on Kauai, on the ridge west of the Hanapepe river.

July (2476).

COIX L. Sp. Pl. 972. 1753.

Coix lacryma-Jobi L. Sp. Pl. 972. 1753.

Escaped from cultivation, and plentiful in ditches, about the Palama part of Honolulu. (2554).

ERAGROSTIS BEAUV. Agrost. 70, *pl. 14, f. 11.* 1812.

Eragrostis hawaiiensis HILLEBR. Fl. Haw. Is. 530. 1888.

A tall, handsome grass, collected on the slopes above Waimea, Kauai, at about 2000 feet elevation, where occasional clumps are found. Hillebrand's type came from Kohala, island of Hawaii.

September 24 (2830).

Eragrostis major HOST. Gram. Austr. **4**: 14, *pl. 24.* 1809.

Occasional clumps of this grass are found growing along the streets of Honolulu, and in yards. It is not recorded from the Islands by Hillebrand.

May 9 (2288); original locality, "Europa australi ad agrorum versuras."

Eragrostis plumosa (RETZ.) LINK, Hort. Berol. **1**: 192. 1827.

Poa plumosa RETZ. Obs. **4**: 20. 1779–91.

This species is common about Honolulu, but was not noticed at any distance from the coast. It is undoubtedly introduced.

March 20 (1962).

Eragrostis variabilis GAUD. Bot. Voy. Uranie, 408. 1830.

Collected on grassy slopes, at 1200 feet elevation, near the Nuuanu Pali, Oahu. Also noticed on the slopes of Konahuanui.

March 23 (1992); original locality, Oahu.

HETEROPOGON Pers. Syn. 2:533. 1807.

Heteropogon contortus (L.) Beauv. in R. & S. Syst. 2:836. 1817.

Andropogon contortus L. Sp. Pl. 1045. 1753.

A common grass on the dry and hot slopes of the lee side of the island of Kauai, growing among lava rocks.

July to October (2522); original locality, "in Indiis."

ISACHNE R. Br. Prodr. Fl. Nov. Holl. 196. 1810.

Isachne pallens Hillebr. Fl. Haw. Is. 504. 1888.

This species was collected on rocks at the base of Hanapepe Falls, but was not seen elsewhere. It hung from the face of a perpendicular rock, where it was continually washed by the small streams of water which trickle down the sides of the rock. Hillebrand's type came from the woods of eastern Oahu.

July 2 (2489).

CHAETOCHLOA Scribn. Bull. No. 4, U. S. Dept. Ag. Div. Agrost. 38. 1897.

[**Setaria** Beauv. Agrost. 113. 1812, not Ach. 1789.]

Chaetochloa glauca (L.) Scribn. Bull. No. 4, U. S. Dept. Ag. Div. Agrost. 39. 1897.

Panicum glaucum L. Sp. Pl. 56. 1753.
Setaria glauca Beauv. Agrost. 51. 1812.
Ixophorus glaucus Nash, Bull. Torr. Bot. Club, **22**:423. 1895.

Very abundant in the Hanapepe river valley, and on adjoining slopes. It is not recorded by Hillebrand, and if introduced since his time, must have spread rapidly, as it is well established, covering the hillsides in many places.

June 29 (2469); original locality, "in Indiis."

Chaetochloa verticillata (L.) Scribn. Bull. No. 4, U. S. Dept. Ag. Div. Agrost. 39. 1897.

Panicum verticillatum L. Sp. Pl. Ed. 2, 82. 1762.
Setaria verticillata Beauv. Agrost. 51. 1812.
Ixophorus verticillatus Nash, Bull. Torr. Bot. Club. **22**:422. 1895.

Established along streets, and in waste ground about Honolulu. Collected at Waikiki.

March 20 (1961).

OPLISMENUS Beauv. Fl. Owar. 2:14, *pl. 58.* 1807.

Oplismenus oahuensis Nees & Meyen, in Steud. Nom. Bot. Ed. 2, 220. 1841.

Common in damp woods, where it grows luxuriantly. Collected on both Oahu and Kauai. Hillebrand calls it *Oplismenus compositus* var. *sylvaticus* Trin.

April to October (2061).

PANICUM L. Sp. Pl. 55. 1753.

Panicum colonum L. Syst. Ed. 10, 870. 1759.

Plentiful about Honolulu, growing along the streets, and in cultivated ground. It was found growing in very dry, and also in wet places. The forms growing in moist or shaded ground were of a more erect growth than the dry ground forms.

March 21 (1978).

Panicum crus-galli L. Sp. Pl. 56. 1753.

Two forms of this wide-spread grass were collected on the edge of a taro pond in Pauoa valley, just outside of Honolulu, one (2384) with long awns, and the other (2384 a) awnless or almost so. The latter may be Hillebrand's variety of *P. colonum.*

Panicum nephelophilum Gaud. Bot. Voy. Uranie, 411. 1830.

Collected above Waimea, Kauai, at 3000 to 4000 feet elevation. Only a few scattered plants were seen, growing on the outskirts of the woods.

October (2850).

Panicum pruriens Trin. Gram. Pan. 191. 1826.

Common on the ridges back of Honolulu, up to about 2000 feet.

March 21 (1972).

PASPALUM L. Syst. Ed. 10, 2:855. 1759.

Paspalum conjugatum Berg. in Act. Helv. 7:129, *pl. 8.* 1772.

The "Hilo grass," very common on the lower slopes below the forests on Oahu. A large, coarse decumbent grass, which grows in such tangles, that walking through it is very fatiguing.

March 21 (1971).

Paspalum orbiculare Forst. Fl. Ins. Austr. Prodr. 7. 1786.

Common on Oahu, where it has the same range as the previous, except that it extends further up the slopes.

March 21 (1971).

POLYPOGON Desv. Fl. Atl. 1:66. 1798.

Polypogon littoralis Sm. Comp. Fl. Brit. 13. 1816.

This species was collected at 1200 feet elevation, at the Nuuanu Pali, six miles from the seashore. It is probably a waif at this point as very little of it was found. Hillebrand records it, but is not certain where it was collected.

April 23 (2201).

STENOTAPHRUM Trin. Fund. Agrost. 175. 1820.

Stenotaphrum secundatum (Walt.) Kuntze, Rev. Gen. Pl. 794. 1891.

Ischaemum secundatum Walt. Fl. Car. 249. 1788.
Stenotaphrum americanum Schrank. Hort. Monac. *pl. 98.* 1819.

Abundant on grassy slopes at the Nuuanu Pali, island of Oahu. It is said to be a good forage plant.

May 24 (2359).

SYNTHERISMA Walt. Fl. Car. 76. 1788.

Syntherisma helleri Nash, n. sp. (*Plate XLIV.*)

Panicum filiforme Hillebr. Fl. Haw. Is. 495. 1888, not L. 1753.

Glabrous throughout, with the exception of the spikelets. Culms 2.5 to 4 dm. tall, erect, or decumbent at the base, slender, somewhat branched; nodes 5 or less, blackish brown; sheaths striate, the lower ones short, longer than the short internodes, the uppermost sheath elongated; ligule membranous, about 1 mm. long, truncate; inflorescence long exserted, the axis 1 cm. long or less; spikes 3 to 8, 4 to 9 cm. long, slender, ascending, approximate at the summit of the culm and often with a single one a short distance below; rachis flat, .5 mm. wide, flexuous toward the apex, short hispid on the margins; spikelets elliptic, 1.5 mm. long, .7 mm. wide, acute, in pairs, one very short-pediceled, the other with a pedicel equalling or slightly shorter than itself, with frequently an additional pediceled spikelet present on the same side of the rachis just above the pairs; first scale wanting; second and third scales membranous, hardly as long as the spikelet, the former a little shorter than the latter, both 7-nerved, the marginal and first nerve on either side of the midnerve pubescent with appressed hairs; fourth scale chartaceous, deep chestnut brown, 1.5 mm. long, acute, enclosing a palet of equal length and of similar texture and color.

Collected on the Island of Oahu, in Pauoa, by Mr. A. A. Heller, in 1895, No. 2321. By Dr. Hillebrand, in the Flora of the Hawaiian Islands, it was considered identical with *Panicum filiforme* L., under which name it there appears. The whole general aspect of the plant and the flat, not triangular, rachis plainly indicate its dissimilarity to that species.

Syntherisma sanguinalis (L.) NASH, Bull. Torr. Bot. Club, **22**: 420. 1895.

Panicum sanguinale L. Sp. Pl. 57. 1753.

Common in cultivated ground about Honolulu. Collected in Pauoa valley, in company with *S. Helleri.*

May 16 (2320); original locality, "in America, Europa australi."

CYPERACEAE.*

BAUMEA GAUD. Bot. Voy. Uranie, 416, *pl. 29.* 1830.

Baumea meyenii KUNTH, Enum. Pl. **2**: 314. 1837.

A plant referred with some doubt to this species, was first collected at about 3000 feet elevation, on the ridge west of the Hanapepe river, Kauai, on an exposed gravelly slope. It was also collected in wet woods along the Wahiawa river, and on the island of Oahu, on the slopes of Konahuanui.

July to October (2651).

CAREX L. Sp. Pl. 972. 1753.

Carex wahuensis C. A. MEYER, Mem. Sav. Etr. Petersb. **1**: 218. *pl. 10.* 1831.

Collected on grassy slopes at 2500 feet elevation, above Waimea, Kauai.

October 10 (2849).

CLADIUM P. BROWNE, Civ. and Nat. Hist. Jam. 114. 1756.

Cladium leptostachyum NEES & MEYEN, Beitr. Bot. Gesell. auf ein Reise, 115. 1843.

Noticed at only one locality, on the left bank of the Hanapepe, opposite the first ford, where a large clump of it was growing. It is recorded as occurring on "all the islands, but by no means frequent."

July 5 (2509); original locality, "in insula Oahu, Sandwicensium."

* The determinations by Dr. N. L. Britton.

CYPERUS L. Sp. Pl. 44. 1753.

Cyperus difformis L.

Common about taro ponds, in Pauoa valley, near Honolulu. Not before recorded from the Islands.

April to June (2003).

Cyperus hawaiiensis MANN, Proc. Am. Acad. 7:208. 1867. Ex descriptio.

On rocks at 1400 feet elevation, at the Nuuanu Pali, where a few plants were collected. This species seems to have been collected only by Mann and Brigham, and by Wawra. The type is Mann and Brigham No. 246, from "the mountains of Hawaii, Maui, and Kauai."

Cyperus hypochlorus HILLEBR. Fl. Haw. Is. 468. 1888. Ex descriptio.

The plant referred to this species is not uncommon in Hanapepe valley, Kauai, in wet places near the river bank, and on grassy slopes. A large, handsome species.

June 29 (2466).

Cyperus laevigatus L. Mant. 2:179. 1771.

Common about Honolulu in wet ground. Specimens were collected at Waikiki, and at Salt Lake.

March to May (1959).

Cyperus pennatus LAM. Tabl. Encycl. 1:144. 1791.

Common in marshes about Pearl city, Oahu, and also in moist places on slopes in the Hanapepe valley, Kauai.

June 10 (2407); original locality, "Java."

Cyperus polystachys ROTTB. Descr. et Icones. 39. 1773.

Common on grassy slopes on Oahu, up to the edge of the forest. Noticed also near Pearl city, in low ground near the coast. It was plentiful also on Kauai.

March to August (1948).

Cyperus rotundus L. Sp. Pl. 45. 1753.

Collected in cultivated ground near Waikiki, outside of Honolulu. It was introduced about 1850.

May 9 (2286); original locality, "India."

Cyperus umbellatus (L.) BENTH. Fl. Hongkong. 386. 1861.

Kyllingia umbellata L. Suppl. 105. 1781.

This plant was collected on a grassy ridge back of Waimea, Kauai, at an elevation of 2500 feet. It was seen in only this one place.

October 1 (2851); original locality, "in Indiis."

ELEOCHARIS R. BR. Prodr. Fl. Nov. Holl. 1: 224. 1810.

Eleocharis ovata (ROTH.) R. & S. Syst. **2**: 152. 1817.

Scirpus ovatus ROTH. Catal. **1**: 5. 1797.
Scirpus obtusus WILLD. Enum. **1**: 76. 1809.
Eleocharis obtusa SCHULTES, Mant. **2**: 89. 1824.

Collected at the foot of Hanapepe falls, on the island of Kauai. It does not seem to differ materially from the widely distributed American plant.

July 2 (2488).

FIMBRISTYLIS VAHL. Enum. 2: 285. 1806.

Fimbristylis polymorpha BOECKL. Linnaea, **37**: 14. 1871.

Collected in Pauoa, Oahu (2385), and along the Hanapepe river, Kauai (2475). Of the forty synonyms of Boeckler, it is a hard matter to decide which is the proper name for the Hawaiian plant. The coining of a new specific name by Boeckler was certainly not admissible, even if there was sufficient ground for uniting all of the species which he cites. It is impossible for me to obtain the proper name for this plant, hence the use of the meaningless term *Frimbristylis polymorpha.*

Fimbristylis umbellato-capitata STEUD.?

Specimens collected at Waikiki, Oahu, within the race track enclosure, where there is a pool of brackish water, seem to belong to the plant which Hillebrand designated as a variety *umbellato capitata* of *F. cymosa*, which is "*F. umbellato-capitata* of Mann, Enum. no. 518, but probably not of Steud." Mann does not state where his specimens were collected. Hillebrand records it from nearly all of the islands, and states that it is found "in higher and exposed localities, and more frequent than the first form" (*cymosa*). Waikiki, where it was collected by me, is practically at sea level.

March 20 (1958).

GAHNIA FORST. Char. Gen. 51, *pl. 26.* 1776.

Gahnia mannii HILLEBR. Fl. Haw. Is. 482. 1888. Ex descriptio.

Plants referred to this species, were collected at 4000 feet above Waimea, Kauai (2840), in dry gravel, near the edge of the plateau. Later it was again collected in damp woods, on the slope of Konahuanui, Oahu (2912). Hillebrand's type came from Lanai.

Gahnia gahniaeformis (GAUD.) HELLER.

Morelotia gahniaeformis GAUD. Bot. Voy. Uranie, 416, *pl. 28.* 1830.
Gahnia gaudichaudii STEUD. Synop. Pl. Gl. **2**: 164. 1855.

It is stated in Hillebrand's Flora, that *Cladium quadrangulare* NEES, Linnaea, 9: 301, is a synonym of this species, but reference to the page cited does not seem to substantiate that view, as *Morelotia gahniaefolia* is given as quite distinct, near the bottom of the page This species was not collected by me.

KYLLINGA ROTTB. Descr. et Ic. 12, *pl. 4, f. 3–4.* 1773.

Kyllinga monocephala ROTTB. Descr. et Ic. 13, *pl. 4, f. 4.* 1773.

Common, from sea level to 2500 feet elevation, on Oahu. Some of the vigorous plants which grow in rich soil in the forests, present a very different appearance from the low, stunted forms which grow in lower and more exposed places.

March to October (1970).

RYNCHOSPORA VAHL. Enum. **2**: 229. 1806.

Rynchospora lavarum GAUD. Bot. Voy. Uranie, 415. 1830.

At an elevation of about 2500 feet, on Konahuanui, Oahu, is a flat place only a few yards in extent, where this species is plentiful. The soil is a stiff clay, so that considerable moisture is retained, instead of rapidly sinking, as is usually the case in the light volcanic soil of the islands. Near the centre of this small space a hole has been dug, in which water can always be found, and on the edge of this hole the plants are thickest. Hillebrand mentions it as growing on the high mountains of East Maui and Hawaii. It must have been collected on Oahu by Lay and Coolie, as it is enumerated in the "Botany Beechy."

May 23 (2343).

Rynchospora sclerioides H. & A. Bot. Beechy, 99. 1832.

Rynchospora thyrosidea NEES & MEYEN, in Kunth, Enum. Pl. **2**: 294. 1837.

Not uncommon on the slopes of Konahuanui, Oahu, in damp woods. A handsome species. The later name of Nees & Meyen seems to have been commonly used in botanical books. Their name of *R. thyrosidea* is used in Linnaea, **9**: 297, 1834, but without description. It is possible that this name has precedence as a label name, but the first description appeared under *R. sclerioides*.

SCIRPUS L. Sp. Pl. 47. 1753.

Scirpus lacustris L. Sp. Pl. 48. 1753.

Common about Honolulu, in brackish water along the beach, and also in fresh water. Specimens were collected along the stream in Nuuanu valley, more than a mile from salt water.

March 30 (2047); original locality, "in Europae aquis puris stagnantibus et fluviatilibus."

Scirpus maritimus L. Sp. Pl. 51. 1753.

A form of this species, called variety *digynus* by Hillebrand, is plentiful in salt marches at Salt Lake, and other places about Honolulu.

April 24 (2208).

Scirpus

At Waimea, Kauai, a *Scirpus* was collected in taro ponds, which has not yet been satisfactorily placed. It is probably an introduced plant, allied to *Scirpus debilis*.

October 23 (2891).

VINCENTIA GAUD. Bot. Voy. Uranie, 417. 1830.

Vincentia angustifolia GAUD. Bot. Voy. Uranie, 417. 1830.

Collected on Konahuanui, Oahn, growing in company with *Rynchospora lavarum*. A large plant with leaves much like those of *Acorus calamus*.

May 23 (2342).

LEMNACEAE.

LEMNA L. Sp. Pl. 970. 1753.

Lemna minor L. Sp. Pl. 970. 1753.

This species, unrecorded for the Hawaiian flora, is very common about Honolulu, in taro ponds, and other bodies of still water. At Capiolani Park, where the specimens were collected, it is especially plentiful.

April 16 (2134); original locality, "in Europae aquis quietis."

CONVALLARIACEAE.

ASTELIA Banks & Sol. in R. Br. Prodr. Fl. Nov. Holl. 291. 1810. (*Plate XLV.*)

Astelia menziesiana Smith, in Rees, Encycl. App. 34.

Rhizome thick, creeping, covered with thin brown scales; flowering stem channeled, two feet high or less, clothed throughout with dense, white wool, simple and leafless up to the inflorescence; leaves closely imbricate at the base of the flowering stalk, which they slightly exceed in length, linear, gradually attenuate, maximum width three-fourths of an inch, clothed on both faces with appressed white hairs, midvein yellowish, prominent beneath, but not noticeable above, the upper side marked with two prominent lateral nerves, and a number of smaller intermediate ones; inflorescence paniculate, the alternate branches two to five inches long, each subtended by a sessile, ovate-lanceolate, acuminate, leafy bract, the lowest one longer than its flowering branch, about equaling the inflorescence, the others successively shorter and broader, and each shorter than the branch which it subtends; pedicels at right angles to the peduncle, stout for the size of the flower, nearly a half inch in length, densely white woolly; bractlet at the base small, shorter than the pedicel; perianth segments purple, oblong, narrowed at the apex, but hardly acute, white wooly on the outside, the three inner ones less so than the three outer ones, and slightly narrower, all three nerved, the outer ones tipped with an incurved protuberance; stamens shorter than the perianth segments; stigmas small, sessile on the narrowed apex of the ovary; ovary ovoid, three-celled, glabrous.

Hillebrand unites this species with *A. veratroides* GAUD., but with very little reason, merely saying that "the forms with more or less glabrate leaves—*A. menziesiana* SM.—are chiefly found at lower elevations," thus leaving one under the impression that the two plants are very similar, when in fact they are totally unlike in size, habit and habitat. I saw at once that my plant was neither *veratroides* nor *Waialealae*, and distributed it as *Astelia argyrocoma* n. sp. (No. 2752). Lately upon having access to Wawra's publications in *Flora*, I find that he has very clearly described *A. menziesiana* in *Flora*, **58**: 242. 1875, and that my specimens undoubtedly belong there. It was found on the Island of Kauai only, in wet woods, at elevations of 3000 to 4000 feet, growing on the reclining trunks of moss-covered trees. Sometimes hundreds of plants can be found on a single trunk. It is common on the ridge west of the Hanapepe river, and on the plateau above Waimea. Wawra records it from Kauai, "on moss-covered trees in the valley of Hanalei, and on Pohakupili and Halemanu." It came into bloom late in August.

A. veratroides is a large species, with leaves three to four feet long, and from three to six inches wide. The flowering stalk is proportionately large and stout. It is plentiful on the ridges back of Honolulu, usually growing on the precipitous edge of a ridge, and only at medium elevations. Very few plants were seen in Kauai, where they grew along the steep banks of a stream in the woods.

DIANELLA LAM. Encycl. **2**: 276. 1786.

Dianella sandwicensis H. & A. Bot. Beechy, 97. 1832.

It is altogether probable that Hooker and Arnott's *D. sandwicensis* is distinct from the *Dracaena ensifolia* of Linnaeus, an Indian plant which one would not expect to find in the Hawaiian Islands. On Oahu it appears to grow only on the ground, at elevations of 2000 to 3000 feet. On Kauai it waa found principally on mossy or decayed tree trunks, ranging from elevations of 2500 to 4000 feet. The Index Kewensis refers it to *Dianella nemorosa* Lamark, published in 1786, of which the earlier *Dracaena ensifolia* L., published in 1767, is said to be a synonym.

May to October (2349).

DRACAENA L. Mant. 1: 63. 1767.

Dracaena aurea MANN, Proc. Amer. Acad. 7: 207. 1867.

Hillebrand says this species is "not uncommon on all islands at altitudes of 1000 to 2500 feet, as in Nuuanu, Oahu, near the Pali." If it ever was common on Oahu, it has become rather scarce during the intervening years. My first specimens were collected at the Nuuanu Pali, where there are several trees, but it is not at all common. On Kauai, it is plentiful between the Hanapepe and Waimea rivers. Above Waimea, on the edge of the tabular summit, at about 3500 feet elevation it is very abundant. One stunted tree was observed in the forest on Kaholuamanoa at 4000 feet. Mann's statement that the berry is red, is much more correct than Hillebrand's designation of it as "yellow." Red-brown is perhaps the proper term. The graceful, palm-like habit of this tree, is quite a contrast to the herbaceous Liliaceous plants of more temperate climes.

May 24 (2362); the type number is M. & B. 362, without exact locality, but probably from Oahu.

SMILACEAE.

SMILAX L. Sp. Pl. 1028. 1753.

Smilax sandwicensis KUNTH. Enum. Pl. 5: 253. 1850.

Pleiosmilax sandwichensis SEEM. Journ. Bot. 6: 193. 1868.

According to Hillebrand this species ranges from Kauai to Maui. Specimens with fully formed but unripe fruit, were collected on the lower slopes of Konahuanui, back of Pauoa, island of Oahu, at an elevation of about 2000 feet. The plant usually forms a dense tangle, climbing over bushes and trees.

May 14 (2312).

DIOSCOREACEAE.

DIOSCOREA L. Sp. Pl. 1032. 1753.

Dioscorea sativa L. Sp. Pl. Ed. 2, 1463. 1763.

This species with its peculiar, potato-like rhizome, is common on the heights of Pauoa, Oahu. On Kauai, it is rather common in Hanapepe valley. Although hundreds of plants were seen, only a few were found in flower, but all, except those in flower, bore bulbs which form in the axils of the leaves. These bulbs are often an inch and a half in diameter.

August 14 (2728), original locality, "in Indiis."

ZINGIBERACEAE.

CURCUMA L. Sp. Pl. 2. 1753.

Curcuma longa L. Sp. Pl. 2. 1753.

In the upper part of Nuuanu valley, at an altitude of about 900 feet, this plant is quite plentiful. The large clusters of yellow flowers present a striking appearance. The plant, as a rule, is about five feet high, leafy to near the summit.

May 24 (2367); original locality, "in Indiis."

ORCHIDACEAE.

LEPTORCHIS Du Petit Thouars, Nouv. Bull. Soc. Philom. 314. 1808.

[**Liparis** L. C. Rich. Mem. Mus. Paris 4: 43. 1818.]

Leptorchis hawaiiensis (Mann) Kuntze, Rev. Gen. Pl. 671. 1891.

Liparis hawaiiensis Mann, Proc. Amer. Acad. **7**: 207. 1867.

This plant was found growing in damp places on Konahuanui, at an elevation of about 2500 feet. On Kauai, it was found at from 3000 to 4000 feet, but always growing on trees which were covered with mosses and hepatics. It is not common, but careful search in favorable situations, will generally yield several specimens.

May to October (2706); no locality given, except "in mountain woods on trees." Type number, M. & B. 471.

ANOECTOCHILUS Blume, Bydr. 411, *t. 15.* 1825.

Anoectochilus sandwicensis Lindl. Gen. and Spec. Orch. 500. 1840.

Hillebrand credits this species as growing "in the lower forests of all islands." On Oahu it was found growing near the summit of Konahuanui, at 3000 feet elevation in what he designated the "middle forest zone," or what on this island is really the "upper forest zone." On Kauai, where it is plentiful near the head of the Wahiawa river, at about 3000 feet elevation, it is certainly in the middle zone. It grows apparently only in wet, almost boggy woods, where both ground and trees are covered with a thick mat of mosses and hepatics. The stems are weak and decumbent.

August 21 (2742).

PIPERACEAE.

PEPEROMIA Ruiz. & Pav. Fl. Peruv. et Chil. Prodr. 8. 1794.

Specimens of all the numbers of this interesting, but difficult genus, were sent to M. Casimir DeCandolle for determination, but, although more than a year has elapsed, no answer has been returned. By the aid of Hillebrands Flora, and such other works as are at hand, I have endeavored to trace the specimens to their proper places, but not always with success.

Peperomia hypoleuca montis-eeka Hillebr. Fl. Haw. Is. 422. 1888. ?

This plant, which was seen only near and on the summit of Konahuanui, Oahu does not answer very well to Hillebrand's description, yet it can hardly be placed under any of the other species mentioned. Ordinarily, the under side of the leaf is brick red, but in some specimens it is whitish. This was more especially true of specimens collected late in the season.

May to November (2243).

Peperomia latifolia Miq. Syst. Pip. 128. 1843.

A common plant at medium elevations on the mountains of Oahu and Kauai. In the living state, the thick, fleshy leaves are often of a red tinge beneath.

April to October (2116).

Peperomia leptostachya H. & A. Bot. Beechy, 96. 1832. ?

The three numbers which may perhaps be referred to this species, grow at low elevations. No. 2010 was collected in Pauoa valley, back of Honolulu. It grew on rocks in exposed situations, below the forest, and was noticed at several places. The stems of these specimens are hirsute throughout. The leaves on the young shoots are opposite, but are whorled on the branches. The plants are erect, and usually not more than eight inches high.

No. 2237 was collected at about 1000 feet elevation in Waialae valley, on the eastern end of Oahu. It grew on the ground under the shade of Kukui trees. These plants were weak and procumbent, many of the stems being fifteen or eighteen inches long. The stems are puberulous instead of hirsute, as in No. 2010. The leaves are also longer.

No. 2510 was collected on rocks along the Hanapepe river, Kauai, at an elevation of perhaps 700 feet. This station is less

exposed than the one in Pauoa, where 2010 was collected, being just on the edge of the forest, and in rich, damp soil. The stems in these specimens are somewhat hirsute, especially on young shoots, where the leaves are in whorls of three or more. It is of erect growth, about eight inches high. The leaves, branches, and flowering spikes disarticulate readily in all three numbers.

Peperomia macraeana C. DC. Seem. Journ. Bot. 4:145. 1866.

Some of the specimens under No. 2338 undoubtedly belong to this species. They were collected at an elevation of about 1500 feet, in wet woods at the head of Kalihi valley, Oahu. The species is perhaps rather common in damp woods.

Peperomia macraeana C. DC. var.

These specimens were collected in wet woods, at an elevation of 3000 feet and more on Kauai, principally on the ridge west of the Hanapepe river. They seem to resemble *P. membranacea* somewhat, but the character of spikes shorter than the leaves, forbids that disposition of them.

July and August (2612).

Peperomia macraeana nervosa HILLEBR. Fl. Haw. Is. 421. 1888.

Above Waimea, Kauai, where Hillebrand's type was collected and near the head of the Wahiawa, were collected specimens which answer to the description of this plant, except the clause "purplish underneath, excepting the course of the nerves." They are whitish underneath in my specimens. The plant is light green instead of dark green as in the species, and has thicker leaves and spikes. It appears to be quite distinct.

Peperomia membranacea H. & A. Bot. Beechy, 96. 1832.

Part of No. 2238, collected at the head of Kalihi valley, Oahu, belongs to this species. It seems to grow only in dense wet woods. The slender spikes, extending much beyond the leaves, the broader and thinner leaves, and the arrangement of the veining of the leaves, distinguish it from *P. macraeana*, specimens of which were collected at the same place, and included under number 2338. Collected May 20th.

Peperomia membranacea H. & A. var.

On the ridge west of the Hanapepe river, Kauai, plants were collected which seem to be referable to *P. membranacea*. The

habit is the same, and the leaves very similar in shape. It also has the same long slender spikes extending beyond the leaves. The main stem likewise is glabrous, but the branches are hirsute. There is a difference also in the veining, for instead of the "five conspicuous basal or sub-basal nerves," there are but three veins, with faint indications of a fourth and fifth on some leaves. The under side of the leaves instead of being glabrous, are hirsute, and the upper side bears a line of hairs on the midrib. It may be Hillebrand's *P. hypoleuca* var. *kauaiensis*, which he says is "intermediate between the present species (*hypoleuca*) and *P. membranacea*," but he describes the plant as having "oblanceolate or oblong" leaves. The leaves of my plant are ovate. Collected in damp woods at an elevation of 3000 feet.

July 29 (2633).

Peperomia reflexa (L. f.) A. Dietr. Sp. Pl. **1**: Ed. 6, 180. 1831.

Piper reflexum L. f. Suppl. 91. 1781.

Three numbers were collected which seem referable to this species. The first (2077), was collected on the heights of Pauoa, Oahu, where it was growing in the forks of Kukui trees. The plants are small and grow in tangled clumps. A second number (2534), is very similar but smaller, and has somewhat thicker spikes. It also grew on Kukui trees, along the Wahiawa and Hanapepe rivers, Kauai. The third number (2481), is much larger in every way. It was found growing only on the ground, first along a tributary of the Hanapepe river, Kauai, and later in the woods at 4000 feet elevation above Waimea.

Peperomia

About a mile above the mouth of the main tributary of the Hanapepe river, Kauai, was collected a plant which does not seem to agree with any of the Hawaiian species, although it seems to be close to *P. sandwicensis*. The plants were growing in wet, muddy ground, at the base of a ledge of rock. They are small, none being over six inches long, including the long spikes. The stems are short, branching from near the decumbent base, somewhat channeled, smooth below, the upper part and the branches, pubescent with short hairs that curve upward. The leaves are in whorls of three, or sometimes the lower ones opposite, on hairy petioles of about one-fourth their length. Including the petiole, the largest are about an inch long, obovate, or almost orbicular in outline, thick, three-

nerved, these often obscured, granular punctate and green above, but not pubescent, except sometimes along the margin or at the junction with the petiole, the under side red, pubescent, with short curved hairs, or occasionally merely granular; spikes very long and slender, commonly as long or longer than the rest of the plant.

July 1 (2478).

Peperomia

Another species from Kauai, which cannot be satisfactorily placed, was first collected at about 3000 feet elevation, on the ridge west of the Hanapepe river, where it was found growing at the base of trees. The plants from this place are small, less than six inches high. The stems are usually simple, but sometimes branched above, slightly channeled, pubescent throughout. The leaves are on short petioles, opposite, or in threes, about an inch in length, thin, lanceolate, with tapering base, three-nerved, or the upper appearing as if one-nerved, hairy on both faces. The spikes are terminal, single, slender, the rachis strongly angled, glabrous, on sparingly pubescent pedicels. Above Waimea, Kauai, at 4000 feet elevation, larger specimens were collected, which also appear to belong here.

July to October (2632).

CASUARINACEAE.

CASUARINA L. Amoen. Acad. **4**: 143. 1759.

Casuarina equisetifolia L. Amoen. Acad. **4**: 143. 1759.

Introduced, and extensively planted in Capiolani Park, near Honolulu.

March 20 (1955).

URTICACEAE.

ADICEA RAF. Ann. Nat. 179. 1815.

[**Pilea** LINDL. Coll. *pl. 4.* 1821.]

Adicea peploides (GAUD.) KUNTZE, Rev. Gen. Pl. 623. 1891.

Dubrueilia peploides GAUD. Bot. Voy. Uranie, 495. 1830.
Pilea peploides H. & A. Bot. Beechy Voy. 96. 1832.

Collected first at the Nuuanu Pali, Oahu, elevation 1200 feet, where it was growing in the crevices of wet rocks. The plants here were dwarfed and small. On Kauai, at Hanapepe Falls,

the plants were large and robust, being kept continually moist by the spray from the falls. Here it grew among the boulders and loose stones which have accumulated at the foot of the falls.

April to August (2200).

BOEHMERIA Jacq. Stirp. Am. 246, *pl. 157.* 1763.

Boehmeria grandis (H. & A.)

Urtica grandis H. & A. Bot. Beechy, 95. 1832.

Boehmeria stipularis Wedd. in Ann Sc. Nat. (IV) **1**: 200. 1854.

That a species native to the Hawaiian Islands should be identical with an African species, is hardly tenable. Hillebrand, after noting some difference between the Hawaiian plant and Weddell's *B. stipularis*, thinks "it is probable that two distinct species lie concealed in the present one (*stipularis*), and that thus the difficulty of explaining the occurrence of only one species in two limited areas which are removed from each other by half the circumference of the globe, will find an easy solution." Nevertheless, he did not attempt a solution, which is certainly easy, for in *Urtica grandis* H. & A., we have a perfectly valid name to apply to the Hawaiian plant On Oahu, it is credited as occurring only on Mt. Kaala, of the Waianae range. On Konahuanui, back of Honolulu, I obtained specimens at an elevation of about 2500 feet (2906), early in November. This is the broad-leaved, apparently typical form. On Kauai, specimens of the variety *gamma* of Hillebrand were collected at Hanapepe Falls, where it is rather plentiful. This form (2436), which is quite constant on Kauai, was again observed in a branch cañon of the Hanapepe, at an elevation of about 1500 feet, and also on Kaholuamano, above Waimea, at an elevation of 4000 feet. It differs from the Oahu plant in being taller and more slender, with narrower and more pointed leaves, which bear but few scattered pilose hairs on the midveins, instead of being markedly hairy on all of the veins. The upper face, too, is merely granular, instead of pilose.

NERAUDIA Gaud. Bot. Voy. Uranie, 500, *pl. 117.* 1830.

Neraudia melastomaefolia Gaud. Bot. Voy. Uranie, 500, *pl. 117.* 1830.

Hillebrand says that this species occurs "on all islands, on dry slopes of the lower regions." My specimens were collected on Kaholuamano, above Waimea, Kauai, at an elevation of 4000

feet, on the banks of a stream in the forest. It is a small tree, about ten feet high, with a distinct trunk, loosely branching above, the weak branches curved, glabrous, or somewhat pubescent where they merge into the inflorescence. This is pretty certainly Gaudichaud's plant, as described by Weddell, in DC. Prodromus, 16: part 1, 235[16], where the leaves are characterized as "very glabrous on both sides, or appressed pilose beneath on the nerves," but what Hillebrand had in view, is not so easy to determine. His description calls for a "low shrub, 3–5 feet high, branching from the base, the spreading, rather nodose branches pubescent with appressed silky hairs." This would apply much better to *N. ovata* or *N. sericea.* He also says that the leaves are on petioles of one-half to two lines In all of the three distinct forms in my collection, the leaves are on petioles of an inch or more in length. Hillebrand says: "The presence of a white milksap rests upon Gaudichaud's statement. I do not remember to have observed it." Gaudichaud's statement is quite correct, as the milky juice was observed in all of the specimens collected by me.

September 24 (2792).

Neraudia sericea GAUD. Bot. Voy. Uranie, 500, *pl. 117.* 1830.

Specimens from above Waimea, Kauai, collected at an elevation of about 2000 feet, agree very well with Gaudichaud's figure in the *Bot. Voy. Bonite, pl. 133*, except that the leaves are a little narrower, and slightly undulate. Wawra's plant, No. 2113, identified as this species, is from the same region.

October 1 (2847).

Neraudia sericea GAUD. var.

Near the base of the tabular summit, above Waimea, Kauai, at about 3000 feet elevation, was found a form which is probably *N. ovata* Gaud., but for the present is referred to *N. sericea.* The leaves are broadly ovate, acuminate, with a rounded and slightly cordate base. It may be *N. melastomaefolia* var. *kauaiensis* Hillebr., but his description calls for a leaf "ovate-rhomboidal, slightly contracting but rounded and even retuse at the base."

October 12 (2881).

PIPTURUS Wedd. Ann. Sc. Nat. (IV) 1:196. 1854.

Pipturus albidus (H. & A.) A. Gray, in Mann, Proc. Am. Acad. 7:201. 1867.

Boehmeria albida H. & A. Bot. Beechy 96. 1832.
Pipturus taitensis Wedd. Ann. Sc. Nat. (IV) 1:197. 1854.

On the mountains back of Honolulu, at elevations of about 2000 feet, this species is rather common, growing on moist and thinly wooded slopes. It is identical with Mann & Brigham's No. 45, upon which Asa Gray founded *Pipturus albidus*. As additional evidence, the Hawaiian plants of the Beechey voyage, were collected on the islands of Oahu and Niihau, and this is a species which is not likely to occur on the latter island, as there is not sufficient rainfall, or great enough elevation. It is a large bush or small tree, with a distinct trunk and loosely spreading branches. The leaves are broadly ovate, thick, crenate from the shortly pointed apex to near the base. The upper surface is irregularly papillose and rough looking, yet to the touch is almost smooth. The under side is covered between the veins with short, dense, white tomentum. The dark veins and veinlets are hirsute. In DeCondolle's Prodromus, Weddell has evidently confused at least two distinct species, and Hillebrand has followed him. The variety *meyeniana* of Weddell is probably nothing more than typical *albidus*, as no other forms were seen on Oahu.

April 11 (2120); probably from the original locality.

Pipturus gaudichaudianus Wedd. Ann. Sc. Nat. (IV) 1:196. 1854.

On Kaholuamano above Waimea, Kauai, at an elevation of 3500 to 4000 feet, is found a plant which answers fairly well to the description of the above species. It is a bush, four to six feet high, with slender, ascending branches. The broadly eliptic-ovate leaf is usually four inches or more in length, crenate, shortly pointed, the upper side smooth in appearance, but rough to the touch, and under a lense appressed pilose and closely granular The tomentum beneath is very close and not nearly so white as in *P. albidus*. Wawra has recorded it from "Maui: Waiheeberge, 1814."

September 2 (2786).

Pipturus kauaiensis n. sp. (*Plate XLVI.*)

A small tree, eight to twelve feet high with spreading top; branches glabrous, except the growing parts, which are tomentose; bark close, light brown; leaves ovate-lanceolate, acuminate, crenate in the upper two-thirds or half, except the acuminate tip, of varying size, but the width commonly half the length, base equal sided, narrowing, or sometimes rounded, the upper side dark green, shortly pilose and granular under a lense, the under side densely covered with short and soft white tomentum, except the veins and veinlets; principal veins three, dark; dioecious; flowers very small, glomerate in the axils of the leaves and branches, the female more numerous than the male; fruit clusters white.

Easily distinguished from *P. albidus* by its thinner, narrower and taper pointed leaves, which are of a different texture, and by the smaller and smoother flower clusters. The branches also are more slender and more regular. Weddell, in DC. Prodr **16**: part 1, 235, as well as Hillebrand, evidently included this very distinct species in their descriptions of *P. albidus*. It is not uncommon in thickets along the Hanapepe river, but does not occur at any great elevation.

June 24 (2428)

Pipturus ruber n. sp. (*Plate XLVII.*)

A small tree, six to eight feet high, with short trunk, and dense spreading top; branches covered with short, gray or tawny hair; leaves alternate, on stout, pubescent petioles, rather thick, ovate or occasionally ovate-lanceolate, acute, crenate from base to apex, upper surface light green, barely roughened, sparingly hirsute only on the three prominent, impressed veins; the under side pale, covered with longer and coarser tomentum than is found on any other species; veins prominent beneath, bright red, but fading when dry, hirsute; female flowers red, densely pubescent, the clusters large.

A handsome species, very distinct from any of the preceding. The numerous clusters of red flowers, and the red veins on the under side of the leaf are very conspicuous in the living plant, but lose their color in the dried specimen. The male plant was not collected. The tomentum on the under surface of the leaves is much darker than in the other species. The flower clusters are even larger than those of *P. albidus*, and the leaves although somewhat similar in texture are much smoother on the upper surface and are of a different shape.

Collected at an elevation of 4000 feet above Waimea, Kauai. It was growing on the banks of a stream in the woods, below Gay & Robinson's Kaholumano house.

October 4 (2852).

TOUCHARDIA Gaud. Bot. Voy. Bon. *t. 94*; Wedd. Monog. Urtic. 441. 1856.

Touchardia latifolia Gaud. Bot. Voy. Bon. *t. 94*; Wedd. Monog. Urtic. 442, *pl. 13, f. C.* 1856.

As the plants figured in the Atlas of the Botany of the Voyage of the Bonite, are unaccompanied by either description or reference to other published species they are all *nomina nuda.* All of them however, seem to have been described by later authors and credited to Gaudichaud. Weddell seems to have been the first who characterized the genus *Touchardia,* with its single species. Collected at Hanapepe falls, Kauai, at an elevation of about 700 feet. The leaves are light green on both faces, not "dark green," as Hillebrand says. They are rugose on both faces, especially on the lower. The prominent veins are red. In the dried specimens the leaves become much darker than in the living state, thus perhaps accounting for Hillebrand's error, but his expression "tripli-nerved, the lateral nerves not reaching the middle of the margin," is not correct. The fact is, that they are simply pinnately nerved, as is plainly shown in Gaudichaud's plate.

July 2 (2485); a Hawaiian genus, said by Hillebrand to occur on all islands.

URERA Gaud. Bot. Voy. Uranie, 496. 1830.

Urera glabra (H. & A.) Wedd. Arch. Mus. Paris. 9:149. 1856.

Procris glabra H. & A. Bot. Beechy, 96. 1832.

Hillebrand calls this variety *gamma,* of *U. sandwicensis* Wedd. In addition to the differences brought out in the description of the two plants, and the very evident dissimilarity to Gaudichaud's figure in Bot. Bon. *t. 92,* we have enough geographical range to separate them. *U. sandwicensis* is known only from the island of Hawaii, while *U. glabra* has a northern range, from Molokai to Kauai. Specimens were collected on Kauai, at the head of the cañon opposite Gay and Robinson's Hanapepe valley house, at an elevation of about 1500 feet, and also at about 3000 feet, at the foot of the tabular summit above Waimea.

July to October (1605); original locality, Oahu.

LORANTHACEAE.

VISCUM L. Sp. Pl. 1023. 1753.

All of the Hawaiian species belong to the section *Aspiduxia*, which is leafless, and perhaps should represent a distinct genus.

Viscum articulatum BURM. f. Fl. Ind. 311. 1768.

If true *Viscum articulatum*, or any other of the species mentioned in DeCandolle's Prodromus, occur in the Hawaiian Islands, the species with flat and rather broad joints, which I found growing only on *Elaeocarpus bifidus* and on the island of Oahu, is apparently referable to it (2212).

To this also must be referred two forms somewhat dissimilar in habit. No. 2183, found growing on the "Ohia ha," or *Eugenia sandwicensis*, is erect, with slender branches, the joints slightly contracting at the base, or of an equal width throughout, the ultimate segments inclined to be pointed. Collected on Konahuanui, Oahu, at an elevation of about 2700 feet.

On the island of Kauai, on the main ridge west of the Hanapepe river, at about 3500 feet elevation, and on Kaholuamano above Waimea, at 4000 feet, occurs a distinct form (2680), much resembling *V. attenuatum* DC. The branches are lax, drooping, spreading, and rather weak. The joints are elongated, narrow, and of an almost even width throughout. The ultimate segments are also somewhat pointed. It grew in dense clusters on the branches of *Elaeocarpus bifidus*. On Kaholuamano it is quite common. The tendency to become disarticulated while drying is very slight in this form.

Viscum pendulum (WAWRA).

> *Vicum moniliforme* BLUME, var. *pendula* WAWRA, Flora (II) **31**: 140. 1873.

The pendulous habit and large size at once distinguish this from all the other forms. It seems to be Hillebrand's *Viscum articulatum* var. *beta*. In the mature plants the joints are an inch or more in width, and not contracted at the point of articulation. In dried specimens, however, the joints shrink considerably. Collected on Kaholumano, above Waimea, Kauai, at an elevation of 4000 feet. It was noticed only on an apparently undescribed species of *Pelea*, which grows near streams in the forest.

September to October (2810); from near the original locality, "Kauai, um Halemanu."

Viscum salicornioides A. CUNN. Ann. Nat. Hist. (I) 2:208. 1839.

To unite this well-marked plant with *V. articulatum*, as Hillebrand has done, is certainly not admissible. The slender, terete joints readily separate it from all of the forms of that species. On Oahu, it was found at the Pali, growing on *Maba sandwicensis*. On Kauai, it occurred only at high elevations, on the "Lehua" tree. A marked peculiarity is that it is found only on trees which grow on the edges of steep slopes, as on the edge of the plateau above Waimea, Kauai.

April to October (2194).

SANTALACEAE.

SANTALUM L. Sp. Pl. 349. 1753.

Santalum ellipticum GAUD. Bot. Voy. Uranie, 442. 1830.

This is the plant referred to by Hillebrand as *S. freycinetianum* var. *delta ellipticum*, and figured by Mrs. Sinclair, in her illustrations of indigenous Hawaiian plants. Collected on the ridge between the Hanapepe and Wahiawa rivers, Kauai, at about 2000 feet elevation. It is not uncommon on the plateau above Waimea. It is a small tree, fifteen to twenty feet high.

August 24 (2579).

EXOCARPUS LABILL. Voy. 1:155, *pl. 14.* 1798.

Exocarpus sandwicensis BAILL. Adansonia, 3:109. 1862.

Exocarpus brachystachys HILLEBR. Fl. Haw. Is. 391. 1888.

Collected on the lower slopes of Waiolani, Oahu, at an elevation of about 2500 feet. A medium-sized, much branched shrub, some branches bearing large leaves, others only the small, scale-like ones. In Proc. Am. Acad. 7:198, Mann cites this as var. *beta foliosa* GRAY, l c. Upon following up the devious track of the l. c., which our forefathers were so fond of using, we find that it refers to "Bot. Expl. Exped. ined." As no description accompanies the name, it is a *nomen nudum*. Anyway, it is antedated by Baillon's name. Very probably *E. casuarinae* BAILL., is only the leafless form of this species, as his type came from Oahu, and there seems to be but one species on that island.

June 6 (2390); type locality, "Insulis Sandwicensibus Lanai et Oahu." Type numbers, Remy, 513, 514.

POLYGONACEAE.

POLYGONUM L. Sp. Pl. 359. 1753.

Polygonum glabrum Willd. Sp. Pl. 2:447. 1799.

Collected along the Hanapepe river, Kauai, at an elevation of about 400 feet. Also observed on Kaholuamano, above Waimea, at an elevation of 4000 feet, growing in a mountain stream in the forest. Hillebrand says the species is "common along streams and water courses." Except the stations mentioned above, I have seen it at only one other place. It grows in the stream in upper Nuuanu valley, a mile or two from the Pali.

June 24 (2423); original locality, "in India orientali."

RUMEX L. Sp. Pl. 333. 1753.

Rumex acetosella L. Sp. Pl. 338. 1753.

In the forest on Kaholuamano, above Waimea, Kauai, this species of *Rumex* is found growing in open places destitute of underbrush. It is not recorded in Hillebrand's *Flora*, and how long it has been on the island I do not know. It is found near Gay & Robinson's mountain house, a place which is used only at intervals, and where nothing whatever is cultivated.

August 30 (2767); original locality, "in Europae pascuis et arvis arenosis."

CHENOPODIACEAE.

CHENOPODIUM L. Sp. Pl. 219. 1753.

Chenopodium murale L. Sp. Pl. 219. 1753.

Specimens were collected at Capiolani Park, within the race-track enclosure, but it is rather common about Honolulu, near the water front. Also was observed at Makaweli, Kauai, near the beach.

March 21 (2024); original locality, "in Europae muris aggeribusque."

Chenopodium sandwicheum Moq. Chenopod. Monogr. Enum. 28. 1840.

Hillebrand cites this species as published "in DC. Prod. XIII, Sect. II, p. 67." Collected on the edge and about the base of the tabular summit above Waimea, Kauai, at elevations of from 3000 to 3500 feet, where it is plentiful. Woody at the

base, with lax, spreading branches, from three to five feet long.

September 2 (2788); original locality, "in insulis Sandwicheis."

AMARANTHACEAE.

AMARANTHUS L. Sp. Pl. 989. 1753.

Amaranthus viridis L. Sp. Pl. Ed. 2, 1405. 1763.

A common plant at Honolulu, in the streets, in gardens, and in waste places. Specimens were collected on Alekea street, and at Capiolani Park.

March to May (2025, 2135); original localities, "Europa Brasilia."

CHARPENTIERA Gaud. Bot. Voy. Uranie, 444, *pl. 47.* 1830.

Charpentiera elliptica (Hillebr.)

Charpentiera obovata Gaud. var. *elliptica* Hillebr. Fl. Haw. Is. 375. 1888.

On Kaholuamano, above Waimea, Kauai, at 4000 feet elevation, this well-marked species occurs along stream banks in the forest, and on the upper edges of steep slopes. It has thick, dark green, oblong-lanceolate, or elliptical-lanceolate leaves, very different in shape and texture from either of the two other species. It is figured by Mrs. Sinclair, in her illustrations of Hawaiian plants, plate 44.

September (2781).

Charpentiera obovata Gaud. Bot. Voy. Uranie, *pl. 48.* 1830.

Just below the second fall of the Wahiawa river, Kauai, elevation about 2000 feet, a small tree of this species was growing. Hillebrand makes no mention of its occurrence on Kauai.

July 22 (2598).

Charpentiera ovata Gaud. Bot. Voy. Uranie, *pl. 47.* 1830.

On the edge of the plateau above Manoa, Oahu, at an elevation of 2000 feet, there are several trees of this species. I did not see it on Kauai. By some writers it is considered a mere form of *C. obovata*, yet, in all cases observed by me, the living plants could be distinguished at a glance. *Ovata* is a larger and more regularly branched tree, has larger, differently shaped and thinner leaves, which turn darker in drying than do those of *C. obovata*.

NOTOTRICHIUM Hillebr. Fl. Haw. Is. 372. 1888.

Nototrichium sandwicense (A. Gray) Hillebr. Fl. Haw. Is. 373. 1888.

Ptilotus sandwicensis A. Gray, in Mann, Proc. Am. Acad. **7**: 200. 1867, as regards Remy's No. 207.

Said to be shrubby. The leaves are thick, opposite, on slender petioles of about one-fourth the length of the blade, sericeous on both sides, especially so beneath, ovate or elliptical-ovate, acute or acuminate; inflorescence corymbose, trichotomous; pedicels slender, as long, or the ultimate ones sometimes twice the length of the spikes. The type is Remy's plant, No. 207. Under this number are two forms, one from Hawaii, with acuminate leaves on slender marginless petioles, the other from Oahu, with bluntish leaves, on margined petioles. On the ridge leading up to Kaholuamano, Kauai, between the forks of the Waimea river, I collected two forms, referable to Remy's plant. One, an erect, compact bush, three to four feet high, with thick, elliptical, mostly obtuse leaves, grew on the open, exposed slope, at an elevation of about 2500 feet. The other grew in the shade, on the banks of a stream in a cañon, at about 2000 feet elevation It is a larger bush, with more spreading branches, the leaves somewhat thinner, elliptical-lanceolate in shape, acute In both of these forms the leaves are on short margined petioles.

September 24 (2831); original localities, "Hawaii, near the coast; Oahu."

Nototrichium viride Hillebr. Fl. Haw. Is. 373. 1888.

Ptilotus sandwicensis A. Gray, in Mann, Proc. Am. Acad. **7**: 200. 1867, in part.

There is not the least doubt about Mann & Brigham's No. 590 being specifically distinct from Remy's No. 207. The former I have seen in the Herbarium of the Bernice Pauahi Bishop Museum, at Honolulu, and the latter in the herbarium of Columbia University. In the publication of *Ptilotus sandwicensis*, the numbers are cited thus: "(M. & B. 590; Remy, 207)." In Hanapepe valley, Kauai, the type locality for M. & B. 590, it is not uncommon at elevations of 300 to 600 feet, usually growing on steep slopes. It is a small tree about ten feet high, with spreading branches. On the living plants, the foliage has a rufous tinge. The leaves are thin, elliptical ovate, acute or acuminate, tapering below into a margined petiole, glabrous above, shortly pubescent beneath, especially the

younger ones. The mature flowering spikes are almost an inch in length on long, slender peduncles. Hillebrand's short description is rather faulty, for his statement that the leaves are "glabrous and green on both faces," is not correct, as evinced by the above description. However, he did not have specimens in his own collection, which may account for any discrepancies.

June 24 (2426).

PHYTOLACCACEAE.

PHYTOLACCA L. Sp. Pl. 441. 1753.

Phytolacca brachystachys MOQ. in DC. Prodr. **13**: part 2, 32. 1849.

In Hillebrand's Flora, this species is said to be "common in the lower forests." It certainly is not common now on Oahu, for none of it was seen on that island. On Kaholuamano, above Waimea, Kauai, it is rather plentiful along streams in the forest, at an elevation of 4000 feet. It can hardly be called an erect "undershrub," as it is woody only at the base, and the herbaceous branches have a decided tendency to droop.

August 30 (2772); original locality, "in ins. Oahu Sandwicensium."

BATIDACEAE.

BATIS P. BROWNE. Civ. and Nat. Hist. Jam. 358. 1755.

Batis maritima L. Sp. Pl. Ed. 2, 1451. 1763.

Collected at Waikiki, near Honolulu, growing in wet sand, near the beach. It is common along the shore on the lee side, and very abundant about the Palama end of Honolulu. Also occurs on Kauai.

June 13 (2412); original locality, "in Jamaicae maritimis salsis."

NYCTAGINACEAE.

BOERHAVIA L. Sp. Pl. 3. 1753.

Boerhavia diffusa L. Sp. Pl. 3. 1753.

Specimens were collected near the beach at Diamond Head, Oahu. Rather common near the coast on the lee side of that island, and was also seen on Kauai.

March 29 (2020); original locality, "in India."

PISONIA L. Sp. Pl. 1026. 1753.

Pisonia sandwicensis HILLEBR. Fl. Haw. Is. 369. 1888.

Staminate specimens were collected at the second fall of the Wahiawa river, Kauai, which is at an elevation of about 2000 feet. Pistillate ones were obtained at the base of the plateau above Waimea, at about 3000 feet elevation. This species is a good sized tree, often twenty-five feet or more in height, with a trunk diameter of eight or ten inches. The male flowers are pinkish in color, and sweet scented. The white or pink tinged perigone, and long-exserted stamens, present a very attractive appearance. The female flowers are much smaller, and greenish.

July to September (2598, 2784). The range is given from Maui to Kauai, but it has not been reported from Oahu.

Pisonia umbellifera (FORST.) SEEM. Bonplandia **10**: 154. 1862.

Ceodes umbellifera FORST. Char. Gen. 71, *pl. 71.* 1776.

Specimens referable to this species were collected on Kauai, on the ridge west of the Hanapepe river, and on the ridge between the Hanapepe and Wahiawa rivers, at elevations of about 2000 feet. The fruit of these specimens was not at all viscid, and did not stick to the paper. But on Oahu, on the edge of the plateau above Manoa, specimens were seen, the fruit of which was very viscid, sticking tenaciously to anything with which it came in contact. Hillebrand says: "The fruiting perigone of all three species exudes a very viscid glue. * * * It will stick fast to paper in the herbarium for years."

June to October (2453); original locality, island of Tanna, New Zealand.

PORTULACACEAE.

PORTULACA L. Sp. Pl. 445. 1753.

Portulaca oleracea L. Sp. Pl. 445. 1753.

Collected at an elevation of about 700 feet, on the hillside opposite Gay & Robinson's Hanapepe valley house. It was also seen at other places, especially in dry ground near Honolulu.

July 6 (2521); original localities, "in Europa australis, India, ins. Ascenscionis."

CARYOPHYLLACEAE.

CERASTIUM L. Sp. Pl. 437. 1753.

Cerastium vulgatum L. Sp. Pl. Ed. 2, 627. 1762.

Cerastium triviale LINK. Enum. Hort. Berol. **1**: 433. 1821.

Hillebrand records this species from Maui only. I found it on Kaholuamano, above Waimea, Kauai, at an elevation of 4000 feet. It differs from the common American form of *C. vulgatum* in being less stout, and more spreading. It is also less pubescent.

September 10 (2804); original locality, "in Scaniae et Europae australioris pratis, areis."

DRYMARIA WILLD. in Roem. & Schultes Syst. Veg. 5: 406. 1819.

Drymaria cordata (L.) WILLD. in Roem. & Schultes Syst. Veg. 5: 406. 1819.

Holosteum cordatum L. Sp. Pl. 88. 1753.

On the ridge west of the Hanapepe river, at an elevation of 3500 feet, and in the depths of the forest, I found a vigorous growth of this plant. I saw it at this station only, and how it got there, in a place frequented only by wild cattle, is a mystery. Introduced it must be, for it is not recorded in Hillebrand's *Flora*, and if it were native, would have a wider range on the island.

July 29 (2636); original locality, "in Jamaica, Surinama."

SCHIEDIA C. & S. Linnaea, 1: 46. 1826.

A genus found only on the Hawaiian group.

Schiedia lychnoides HILLEBR. Fl. Haw. Is. 36. 1888.

Collected in the forest, on the plateau above Waimea, Kauai, at an elevation of 4000 feet. Occasionally it grew on the ground, but usually on mossy logs or on trees. As suggested by Hillebrand, there may be grounds for uniting this and *S. viscosa* with the genus *Alsinidendron*, as their large flowers and general habit somewhat remove them from the other members of the genus. The seeds are minutely roughened, not smooth, as stated by Hillebrand.

September 7 (2796); original locality, "Kauai, above Waimea."

Schiedia spergulina A. GRAY, Bot. U. S. Expl. Exped. **15**: 135. *pl. 11.* 1854.

On dry slopes above the Hanapepe river, at elevations of 300 to 1000 feet, this species is rather plentiful. It grows on basalt outcrops only. Some of my specimens differ from the original description, probably owing to the fact that the flowers are dimorphous, a point which is not brought out by either Gray or Hillebrand. The latter, it seems, did not have a specimen in his collection. In my specimens, the sepals are ovate, acute, smooth, except the margins, which are ciliate. In flowers which have long styles, the staminodia are but half the length of the sepals, while they are about as long as the sepals in flowers which have short styles. The number of styles is variable. Sometimes there are three and sometimes four.

June 26 (2446); original locality, "mountains of Kauai."

Schiedia stellarioides MANN, Proc. Bost. Soc. Nat. Hist. **10**: 153. 1866.

This species grows in thick bunches. It has a suffruticose base, but the branches are herbaceous, procumbent, weak and spreading. Collected on Kaholuamano, above Waimea, Kauai, at an elevation of 4000 feet. It is rather plentiful in open places near the edge of the woods.

August 30 (2766); from the original locality, "on the mountains above Waimea, Kauai."

SILENE L. Sp. Pl. 416. 1753.

Silene gallica L. Sp. Pl. 417. 1753.

Hillebrand had this species from the "northern slope of Kaala, Oahu." I collected it at the Nuuanu Pali, where it is found growing along the roadside, as well as clinging in crevices, high up on the cliffs. A few plants were also noticed near the edge of the plateau, above Waimea, Kauai. Here it was growing in pasture land, at an elevation of 4000 feet.

April 23 (2202); original locality, "in Gallia."

RANUNCULACEAE.

RANUNCULUS L. Sp. Pl. 548. 1753.

Ranunculus mauiensis A. GRAY. Bot. U. S. Expl. Exped. 15:11. 1854.

Although the Kauai form differ somewhat from the type, collected on Maui, in having narrower and more dissected leaves, and has more pubescence, it cannot well be separated. The plants are erect, spreading. In general appearance and habit, it is more like *R. recurvatus*, than the plants which have been promiscuously called *R. repens*, and to which Hillebrand likened it. Specimens were collected on the ridge west of the Hanapepe river, at 3500 feet elevation, where it occurs sparingly, and also on Kaholuamano, above Waimea, where it is plentiful in the forest at an elevation of 4000 feet. None of the plants were in good condition, however. It was originally desinated as var. *beta*.

July to September (2635); original locality, "mountains of Kauai."

LAURACEAE.

CASSYTHA L. Sp. Pl. 35. 1753.

Cassytha filiformis L. Sp. Pl. 35. 1753.

This peculiar, leafless plant, with the habit of a *Cuscuta*, is plentiful on the left bank of the Hanapepe river, just above Gay & Robinson's house. It twines over the grass and Guava bushes in dense tangled masses.

August 14 (2729); original locality, "in India."

CRYPTOCARYA R. BR. Prodr. Fl. Nov. Holl. 402. 1810.

Cryptocarya mannii HILLEBR. Fl. Haw. Is. 382. 1888.

A small tree, ten to fifteen feet high, which is rather common in the woods of Kaholuamano, above Waimea, Kauai, at an elevation of 4000 feet. The fruit is crowned by the remains of the perigone, or at least has a well developed projection, a point about which Hillebrand was not certain.

October 4 (2854); from the original locality, "mountains above Waimea, Kauai."

CRUCIFERAE.

LEPIDIUM L. Sp. Pl. 643. 1753.

Lepidium owaihiense C. & S. Linnaea, **1**: 32. 1826.

Collected at the Nuuanu Pali, Oahu. The gnarled and tough woody stems of this species present quite a contrast to the herbaceous species which are found in America. The inflorescence is pubescent, a fact which Hillebrand does not note. Specimens were collected at an elevation of 1400 feet, growing near the edge of the precipice, on the Konahuanui side. It is said to grow on all of the islands of the group.

May 24 (2365).

Lepidium serra MANN, Proc. Am. Acad. **7**: 149. 1867.

Neither Mann in his description of the type, nor Hillebrand in his *Flora*, tell us anything definite about the habit of this species. Both say, "a straggling, much-branched shrub, 2–3 feet high," which is correct, so far as it goes. I have seen the plant at three stations, the first at the original locality, along the Hanapepe river, not far below the falls; along the main tributary of the Hanapepe, and on the edge of the plateau above Waimea. Plants were plentiful enough at all these places, but difficult to collect on account of their growing on the faces of perpendicular rocks, and at some distance from the ground. They usually grow in clumps, and have drooping branches. The stems are simple, and naked for nearly their whole length, only near the end bearing a profusion of linear-lanceolate leaves, and long, drooping, many flowered peduncles. The slender pedicels are puberulent. Speaking of the pods, Mann says: "Maturis oblato-orbiculatus, stylo exemarginatura minima vix exserto," and Hillebrand gives the character, "silicule flat, suborbicular, not emarginate." In my specimens there are varying degrees of emargination, but the styles are decidedly exserted in all cases, when uninjured. There is a specimen of Mann's plant in the Bernice Pauahi Bishop Museum, at Honolulu.

June 24 (2427); from the original locality, "Hanapepe. Kauai."

CORONOPUS Gaertn. Fr. & Sem. **2**: 293. 1791.

Coronopus didymus (L.) J. E. Smith, Fl. Brit. **3**: 691. 1806.

Lepidium didymum L. Sp. Pl. Ed. 2, 92. 1767.

Senebiera didyma Pers. Syn. **2**: 185. 1807.

A few plants of this species were first seen on the slopes of Makiki, along the Tantalus road. It is rather common about the streets of Honolulu.

March 21 (1974).

CAPPARIDACEAE.

CLEOME L. Sp. Pl. 671. 1753.

Cleome pentaphylla L. Sp. Pl. Ed. 2, 938. 1763.

Gynandropsis pentaphylla DC. Prodr. **1**: 245. 1824.

Collected at Honolulu, near a lumber pile at the foot of Alekea street, It is said to be common along roadsides near Honolulu, but I saw it only at the above mentioned place. Hillebrand says it is a native of Africa, but Linnaeus gives its habitat as "in India."

March 27 (2015).

SAXIFRAGACEAE.

BROUSSAISIA Gaud. Bot. Voy. Uranie, 479, *pl. 69.* 1830.

Broussaisia arguta Gaud. Bot. Voy. Uranie, 479, *pl. 69.* 1830.

A bush or small tree, and common on the slopes of Konahuanui, back of Honolulu. It was also collected in the forests of Kauai. Hillebrand says: "In the specimens from Kauai, the serratures of the leaves are straight." In my specimens, from the ridge west of the Hanapepe river, the serratures are smaller than in the Oahu specimens, but are incurved in precisely the same manner.

May to September (2302).

PITTOSPORACEAE.

PITTOSPORUM Banks, in Gaertn. Fr. & Sem. **1**: 286, *pl. 59.* 1788.

Pittosporum acuminatum Mann, Proc. Am. Acad. **7**: 152. 1867.

Specimens were first collected on the ridge west of the Hanapepe river, Kauai, but unfortunately were gathered from two

different trees and it is possible that the majority of them may represent a different species, or at least a marked form. They are under No 2456. Later, specimens were collected at the type locality, "on the mountains above Waimea, Kauai." This is No. 2783, and may be considered typical, except that the petioles are slightly shorter than Mann's measurement. It is a beautiful species, with glossy, light green, thick leaves, not "thin chartaceous," as Hillebrand has it. His character of "spathulate" is not so good either, as Mann's original "oblanceolatis." The type is M. & B. 603.

Pittosporum glabrum H. & A. Bot. Beechy, 110. 1832.

On fruiting specimens, collected in Nuuanu valley, some of the older leaves are rounded, but the younger ones on the same branch are slightly contracted at the apex. None of them are acuminate, nor is there any warrant apparently for Hillebrand's description of "acuminate." Hooker & Arnott say: "Foliis oblongo-obovatis obtusis basi attenuatis utrinque glaberrimis supra nitidis." In flowering specimens, collected on the lower slope of Konahuanui, and overlooking Nuuanu, the pedicels are pubescent. With the exception of this pubescence, which apparently soon disappears, the specimens agree very well with the original description of *P. glabrum.*

March to May (1985); original locality, Oahu.

Pittosporum kauaiense HILLEBR. Fl. Haw. Is. 25. 1888.

This striking species was collected on the ridge west of the Hanapepe river, Kauai, at an elevation of about 2500 feet. It is a good sized tree, and one of the largest species. The pubescence on the under side of the leaves in my specimens is floccose, and seems to disappear on the older leaves. The capsules are small, not tuberculate, and covered with short, white tomentum.

July 17 (2580); original locality, "Kauai mountains of Waimea."

ROSACEAE.

OSTEOMELES LINDL. Trans. Linn. Soc. **13**: 98. 1822.

Osteomeles anthyllidifolia (SMITH.) LINDL. Trans. Linn. Soc. **13**: 99. 1822.

Pyrus anthyllidifolia SMITH, in Rees Cycl. 29.

No. 2195 was collected April 23d, on the steep, wind swept slopes of the Nuuanu Pali, Oahu. Owing to its constant strug-

gle with the strong winds which sweep across this place, the plants have become dwarfed and prostrate, forming a dense, entangled clump, which rises barely a foot above the ground. The branches are several feet long. Perhaps the strangest feature is the black fruit. No. 2238, collected on a sheltered slope in Waialae valley, eastern Oahu, was an erect shrub, four or five feet high, with white berries, as is ordinary.

MIMOSACEAE.

ACACIA ADANS. Fam. Pl. 2: 319. 1763.

Acacia farnesiana WILLD. Sp. Pl. 4: 1083. 1806.

Common on the hot dry slopes of the lee side of Oahu near Honolulu. Here it never attains the size of a tree, but is always shrubby. Specimens were collected at the base of Punchbowl, back of Honolulu.

March 25 (1996); original locality "in Domingo."

Acacia koa A. GRAY. Bot. U. S. Expl. Exped. **15**: 480. 1854.

This is the "Koa" of the natives. It is a large tree, with far-spreading branches, but very often has a comparatively short trunk, as the branching begins at a distance of eight or ten feet from the ground. From the trunks of this tree, the natives used to make their large war canoes. The wood is susceptible of a high polish, and makes very handsome articles of furniture. The woodwork and cases in the Bernice Pauahi Bishop Museum, Honolulu, are made of Koa wood. On Oahu and Kauai it is common in the lower forest, the dark green of its foliage contrasting well with the light green of the Kukui tree. True leaves are rarely seen, as they occur only on young trees, and sometimes as adventitious shoots. Their place is taken on full grown trees by scythe-shaped phyllodia. The species is found only on the Hawaiian group.

March 23 (1984).

LEUCAENA BENTH.; HOOK. Journ. Bot. 4: 416. 1842.

Leucaena glauca (L.) BENTH.; HOOK. Journ. Bot. 4: 416. 1842.

Mimosa glauca L. Sp. Pl. Ed. 2, 1504. 1763.
Acacia glauca WILLD. Sp. Pl. **4**: 1075. 1806.

Introduced, and very abundant about Honolulu. A small tree, with spreading slender branches, which bear an abundance of cream colored flower heads.

March 29 (2048); original locality, "in America."

PROSOPIS L. Mant. 10. 1763.

Prosopis

A species of *Prosopis* is common about Honolulu, flourishing best in hot, dry situations, and having the same range as *Acacia farnesiana.* By Hillebrand it is said to be "*Prosopis juliflora* DC. or *P. dulcis,* Kunth." It is certainly very distinct from the species called *juliflora* in the southwestern part of the United States, although it has a similar pod. The leaflets are short and pubescent, as compared with the long, smooth ones of the American plant. *P. dulcis* KUNTH, is described as having a torulose pod, which forbids its being a synonym of *P. juliflora.*

March 25 (2001).

CAESALPINIACEAE.

CAESALPINIA L. Sp. Pl. 380. 1753,

Caesalpinia bonduc (L.) ROXB. Hort. Beng. 32. 1814.

Guilandina bonduc L. Sp. Pl. 381. 1753.

Hillebrand unites this with *Caesalpinia bonducella* Even the most casual examination of dried specimens shows that the two are abundantly distinct. As opposed to *bonducella,* the branches are more climbing, glabrous, armed with fewer, shorter, and straighter prickles. The leaves are broader, blunter, and smooth. The inflorescence is naked, and the flowers fewer and much larger. It seems to be rare on the islands. A single vine, for it grows much like a grape vine, was found climbing over the limbs of a fallen Koa tree, on the main ridge west of the Hanapepe river, Kauai, at an elevation of about 2500 feet.

July 11 (2541); original locality, "in Indiis."

Caesalpinia bonducella (L.) FLEMING, As. Res. **11**: 159. 1810.

Guilandina bonducella L. Sp. Pl. Ed. 2. 545. 1763.

In the valley of the Hanapepe river, Kauai, this species is common. In habit it is trailing rather than climbing. The stems are numerous, twining and interlacing, so as to form an impenetrable clump three or four feet high. The stems and branches are pubescent, with short, tawny hairs, and provided with numerous prickles, which curve downward. The leaflets are comparatively narrow, acute, and pubescent beneath. The inflorescence is heavily bracted, the flowers small and crowded.

June 26 (2477); original locality, "in Indiis."

CASSIA L. Sp. Pl. 374. 1753.

Cassia chamaecrista L. Sp. Pl. 379. 1753.

Determined as above by Mr. C. L. Pollard. It is plentiful about Honolulu, and is especially so on the dry slopes of Punchbowl and Makiki. It must have been introduced since 1870, as Hillebrand makes no mention of its occurrence on any of the islands.

March 21 (1969),

Cassia gaudichaudii H. & A. Bot. Beechy, 81. 1832.

This, the only native species on the Islands, was first collected by me on the dry slopes of Diamond Head, and at the Pali, island of Oahu. On Kauai it was collected along the Hanapepe river, and on the main ridge west of the Hanapepe. It was not found above 1500 feet elevation, and was nowhere plentiful.

March to July (2022).

Cassia occidentalis L. Sp. Pl. 377. 1753.

Occasionally met with about Honolulu, but apparently not common. Observed also on Kauai, in Hanapepe valley.

April to August (2174); original locality, "in Jamaica."

Cassia laevigata Willd. Enum. Hort. Berol. 441. 1813.

Hillebrand mentions this species as an occasional escape from gardens. Since his departure from Honolulu in 1870, it has spread and become well established at different points. It is common about Honolulu along roadsides, where it climbs over fences and trees. Near the eastern end of Oahu it is plentiful along the road, at some distance from houses. On Kauai it was found at an elevation of 3000 feet, growing in a deep forest. The seeds may have been carried there by wild cattle, but they rarely range low enongh to get into cultivated ground, or even into the pastures of the domesticated cattle.

May to September (2295).

PAPILIONACEAE.

CANAVALIA Adans. Fam. Pl. 2:325. 1763.

Canavalia galeata Gaud. Bot. Voy. Uranie, 486. 1830.

Collected on grassy slopes above Waimea, Kauai, at an elevation of 2500 feet. It is said to grow in forests of all the islands of the group, "twining on trees, often to a great height." At this station it trailed over the ground.

September 25 (2827).

CRACCA L. Sp. Pl. 753. 1753.

[**Tephrosia** PERS. Syn. **2**: 328. 1807.]

Cracca purpurea L. Sp. Pl. 752. 1753.

Galega piscatoria AIT. Hort. Kew. **3**: 71. 1789.
Tephrosia leptostachya DC. Prodr. **2**: 251. 1825.
Tephrosia adscendens MACFAD. Fl. Jam. 257. 1837.
Tephrosia tenella A. GRAY, Pl. Wright. **2**: 36. 1853.

A plant which was formerly of considerable use to the natives. It possesses a narcotic property and was used to stupefy fish. It is common on the dry western slope of Diamond Head, Oahu, and was also noticed on Kauai, along the road between Waimea and Hanapepe. It is not found far from the coast.

March 28 (2023); orignal locality, Ceylon.

CROTALARIA L. Sp. Pl. 714. 1753.

Crotalaria assamica BENTH.; HOOK. Lond. Journ. Bot. **2**: 481. 1843.

Recorded by Hillebrand from "Oahu, Pauoa, at the head of the valley." It is still found there in great abundance, and does not seem to have been carried to other localities. The mature seeds are large, dark olive in color.

October 5 (2911); original locality, "Assam."

Crotalaria fulva ROXB. Fl. Ind. **3**: 266. 1832

This tall, shrubby species, with large, yellow flowers much like those of *C. assamica*, has a pod very different from the other species which grow on the islands. The plant is plentiful along the roadside in Nuuanu valley, but is not recorded by Hillebrand.

The Index Kewensis gives Hort. Beng. 54, as the place of publication, but J. G. Baker, in Fl. Brit. India, **2**: 80. 1879, cites it as given above.

March 23 (1983a).

Crotalaria incana L. Sp. Pl. 716. 1753.

Very common abont Honolulu, growing along roadsides, in fields, and even on the outskirts of the forest on Tantalus. A branching, straggling shrub, the young branches herbaceous and tomentose. Pod short, tomentose, almost black when mature. Seeds olive green when ripe. Not previously recorded from the Hawaiian Islands. It has perhaps been introduced from Australia, as it occurs there.

March 21 (1966); original locality, "in Jamaica and Caribaeis."

Crotalaria longirostrata H. & A. Bot. Beechy, 285. 1841.

This handsome species has not spread much during the past thirty-five years. Hillebrand notes it as growing along "a roadside in Nuuanu valley and on the Waikiki plains near Honolulu, escaped from the Agricultural Society's garden." I have seen it only at the Nuuanu station. The flowers are rather large, bright orange yellow, the keel marked with red. The seeds are small, blackish.

March 29 (2033); original locality, "Talisco," Mexico.

Crotalaria saltiana ANDR. Bot. Rep. *pl. 648.* 1811.

Crotalaria striata DC. Prodr. **2**: 131. 1825.

A common weed about the streets of Honolulu, in waste ground, and in fields. It occurs also at an elevation of 2000 feet on Tantalus, growing on the edge of the woods. It has evidently been in the island since 1865, as there is a specimen in the Mann and Brigham collection at the Bernice Pauahi Bishop Museum, under the name of *C. longirostrata.* The Mann and Brigham plants were collected in 1865. The seeds of this species are yellowish. This species and *C. incana* have spread much more rapidly than any of the other species, as they can be found almost anywhere in the neighborhood of Honolulu. It is an East Indian species, not previously recorded as occurring in the Islands.

April 4 (2071).

Crotalaria spectabilis Roth, Nov. Pl. Sp. 341. 1821.

Crotalaria sericea RETZ. Obs. Bot. **3**: 26. 1779–91, not Burm. f. Fl. Ind. 156. 1768.

Collected in Nuuanu valley along the roadside, and in open lots in the northwestern part of Honolulu. It is herbaceous, with stout, branching, glaucous stems. The flowers are large, an inch or more in length, bright yellow. The seeds are large, blue-black.

March 29 (2029); original locality, "India occidentali."

ERYTHRINA L. Sp. Pl. 706. 1753.

Erythrina monosperma GAUD. Bot. Voy. Uranie, 486, *pl. 114.* 1830.

This, the "Wiliwili" tree of the natives, is rather a strange looking object when in full bloom, although very handsome. The large flowers, which grow in dense clusters on the ends of the leafless branches, are either of a brick red or pale yellow

color. The leaves do not appear, as a rule, until after the flowers have dropped. There are a number of trees on the grassy slopes along the Hanapepe river, Kauai. It was not seen on Oahu.

June 24 (2445).

INDIGOFERA L. Sp. Pl. 751. 1753.

Indigofera anil L. Mant. 272. 1767.

Common in the valleys and on the slopes back of Honolulu. The specimen in the Mann and Brigham collection, at the Bernice Pauahi Bishop Museum, Honolulu, is not this species as labeled, but probably *I. tinctoria*, as it has a straight pod. *I. tinctoria*, according to Hillebrand, has been introduced but was not seen by me.

March 21 (1967); original locality, "in Indiis."

MEDICAGO L. Sp. Pl. 778. 1753.

Medicago intertexta MILL. Gard. Dict. Ed. 8. No. 4. 1768.

Rather common about Honolulu, in yards, gardens, and grassy places along the streets, but not noticed at any distance from cultivated land. Flowers small, yellow. The creeping stems are often three or four feet long. Not recorded as growing in the Hawaiian Islands. The *Index Kewensis* says that *M. intertexta* WILLD. Sp. Pl. **3**: 1411, is equal to *M. ciliaris* CROCK., a name which has been used four times in the genus. Whatever the latter plant may be, *M. intertexta* of Willdenow is identical with Miller's plant, and was not published as a new species, as can readily be seen by referring to the Species Plantarum, where Willdenow says: "Medica leguminibus cochleatis spinosissimus, aculeis utrinque tendentibus, Mill. Dict. n. 4."

March 22 (1982).

MEIBOMIA ADANS. Fam. Pl. 2: 509. 1763.

[**Pleurobolus** ST. HIL. Bull. Soc. Philom. 1812, 192. 1812.]
[**Desmodium** DESV. Journ. Bot. **3**: 122. 1813.]

Meibomia triflora (L.) KUNTZE, Rev. Gen. Pl. 197. 1891.

Hedysarum triflorum L. Sp. Pl. Ed. 2, 1057. 1763.
Desmodium triflorum DC. Prodr. **2**: 334. 1825.

This diminutive species must be much more common than formerly. Hillebrand says that it grows "on the Waikiki plains near Honolulu, and probably elsewhere, in spring." It

seems to be most abundant on hot, dry slopes, as around Salt Lake and Diamond Head. Also common in moist ground in Pauoa valley, where specimens were collected. Noticed also on Kauai, near Hanapepe, where it grew along the roadside. There is a superficial resemblance between it and *Lespedeza striata.*

Map 16 (2323); original locality, "in Indiis."

Meibomia uncinata (JACQ.) KUNTZE, Rev. Gen. Pl. 197. 1891.

Hedysarum uncinatum JACQ. Hort. Schoenb. **3**: *pl. 298.* 1798.
Desmodium uncinatum DC. Prodr. **2**: 331. 1825.

Abundant in rich, damp ground, ranging from the valleys near Honolulu, to an elevation of 2000 feet or more, on Tantalus. An erect or reclining perennial herb, with white or purple tinged, rather large flowers.

March 21 (1968).

PHASEOLUS L. Sp. Pl. 723. 1753.

Phaseolus semierectus L. Mant. 100. 1767.

Common in rich ground about Honolulu, especially at the northern base of Punchbowl. A long stemmed, herbaceous plant, with dark red flowers, which open fully only in the afternoon. A lower and stouter form (2096), was collected on the beach at Diamond Head. No specimens of *P. truxillensis* were found, which is recorded as growing at Diamond Head.

March 25 (1997); original locality, "in America calidiore."

OXALIDACEAE.

OXALIS L. Sp. Pl. 433. 1753.

Oxalis corymbosa DC. Prodr. **1**: 696. 1824.

Oxalis martiana ZUCC. Denkschr. Akad. Muench. **9**: 144. 1823–24.

This handsome species has become well established in the neighborhood of Honolulu, and is even found on the outskirts of the forest. In the matter of nomenclature, I have followed the Index Kewensis, the author of which probably has data to prove that the specific name *corymbosa* was published previous to the apearance of Zuccarini's name, which, accepting this view, must have been published during the latter part of 1824.

April 9 (2098); original locality, "in ins. Borboniae et Mauritii."

Oxalis corniculata L. Sp. Pl. 435. 1753.

A common plant in the streets and gardens of Honolulu, but it has also found its way into the lower forest, and grows luxuriantly in the rich soil. A prostrate, spreading plant, with wirey branches.

April 19 (2159); original locality, "in Italia, Sicilia."

ZYGOPHYLLACEAE.

TRIBULUS L. Sp. Pl. 387. 1753.

Tribulus cistoides L. Sp. Pl. Ed. 2, 703. 1763.

Abundant in sand at Diamond Head, and at other places near the beach. It is found on all of the islands of the group. A handsome species, but not pleasant to handle, on account of the sharp spines on the fruit.

March 28 (2018); original locality, "in America calidiore."

RUTACEAE.

PELEA A. GRAY, Bot. U. S. Expl. Exped. 15: 339. 1854.

In the Index Kewensis, *Pelea* is united with *Melicope*, and if rightly so, the latter name has precedence, and must be used. But in Hillebrand's discussion, which is probably correct, he points out enough differences to keep the Hawaiian plants distinct. He says: "From *Melicope*, on the other hand, they are distinguished, aside from the valvate aestivation of the petals, by the terminal style, not basal or lateral as in that genus, and by the stigma, which is capitate in *Melicope*, but divided into four filiform branches in *Pelea*."

Pelea anisata MANN, Proc. Bost. Soc. Nat. Hist. **10**: 314. 1866.

The leaves of the "Mokehana," as this species is called by the natives, are used for making a mixture for coughs and colds. On the plateau above Waimea, Kauai, a low, shrubby form was collected, which answers very well to the original description: "In general appearance resembling *P. oblongifolia*, but perfectly distinguished by its overpowering anisate odor when the leaves are bruised or the bark peeled off. * * * Leaves elongated oval or olong, obtuse, somewhat attenuate at the base, two to seven inches long, one to two inches wide." At this place the two species were growing close together, and resembled each other very closely. In a cañon at the head of

the main tributary of the Hanapepe river, a somewhat different form was collected. The specimens are from a tree fifteen feet high. The leaves are large, with rounded or retuse apex, the largest four inches wide and six inches long. A number of trees were noticed in the vicinity. The species has been found only on Kauai.

July to October (2609).

Pelea auriculaefolia A. Gray. Bot. U. S. Expl. Exped. **15**: 343, *pl. 36.* 1854.

Platydesma auriculaefolia Hillebr. Fl. Haw. Is. 72. 1888.

Hillebrand has transferred this species to the genus *Platydesma*, but seemingly without good reason. He indicates that he has specimens of this species from the island of Hawaii, from the "Kohala range above Waimea (Hbd,)" and from "woods of Laupahoehoe," collected by Lydgate. He says, "the description of the fruit according to Gray." He evidently never saw a fruiting specimen, and one would think had never consulted the excellent plate in the atlas of the Botany of the Exploring Expedition, or the original description. Yet, speaking of *Pelea sandwicensis*, he says: "In Gray's figure, the capsule is not correctly given, in fact it hardly differs there from that of *P. volcanica* on the next plate." Whatever inaccuracies there may be in this figure, no one should for an instant consider the two figures very similar, as the shape and size of the capsules is noticeably different. The inflorescence of *Platydesma* is very different from that of *Pelea*, and the flowers, so far as I have observed, are much larger. The difference between the fruit of the two genera is so marked, that a blind man could readily distinguish them by the touch. The explanation for this slip on the part of Hillebrand, must be that he had specimens of an undescribed *Platydesma*, and erroneously referred it to *Pelea auriculaefolia*.

Pelea clusiaefolia A. Gray, Bot. U. S. Expl. Exped. **15**: 340, *pl. 35.* 1854.

Clusia sessilis H. & A. Bot. Beechy, 80. 1832, not Forst.

A species which is common in the type locality, "mountains behind Honolulu, Oahu." Usually a small tree, but sometimes shrubby. In my specimens, the leaves are all opposite. Some of the specimens, No. 2303, which are in flower only, were distributed as "*Pelea Sandwicensis*." Comparison with the original description, and with the plate, convince me that they are *P. clusiaefolia*.

May to November (2303, 2348).

Pelea cruciata n. sp. (*Plate XLVIII.*)

A small tree, ten to fifteen feet high, with stout trunk and rough bark; branches spreading, stout, with rough, grayish bark, the young growing portions pubescent with tawny hairs; leaves opposite, on stout angled petioles of about an inch in length, thick, elliptical, rounded at both ends, or somewhat contracted at the base, often slightly notched at the upper end, three to five inches long, two to three inches wide, shortly pubescent above with scattered hairs, covered below, especially on the stout midrib, with tawny hairs; secondary veins parallel, at right angles to the midrib, and losing themselves near the margin in the wavy, intramarginal nerve; veinlets prominent; peduncles usually situated below the leaves in the axils of fallen leaves, less than half an inch long, stout, grooved, two or three flowered; mature capsule with thick walls, deeply four parted, the lobes curved, the whole capsule shaped much like a Swiss cross, with a diameter of an inch.

The type is No. 2809, collected at 4000 feet on Kaholuamano, above Waimea, Kauai. It was growing in the forest along the banks of a stream. At first it was thought referable to *P. kauaiensis* Mann, but Mann's description calls for a "small capsule," while these are large. It is doubtful whether Hillebrand's description of *P. kauaiensis* applies to the true plant, as there is considerable difference between his and Mann's descriptions. Mann's type came from "Kauai, on the mountains above Waimea, at the elevation of 3000 feet," but there is nothing to indicate whether it was from the same locality as mine, namely, between the forks of the Waimea river, or on the plateau of Halemanu, west of the Waimea, where Hillebrand's specimens were collected by Knudsen. Hillebrand says that the "leaves bear a suspicious resemblance to *P.* (*Melicope*) *barbigera*, from the same region."

Pelea microcarpa n. sp. (*Plate XLIX.*)

A small tree, about ten feet high, with moderately rough, grayish bark; loosely branched above, the slender branches more or less curved upwards, only the short growing ends pubescent; leaves in threes, near the ends of the branches, on plano-convex petioles of almost an inch in length, spatulate-obovate, or merely obovate, obtuse or retuse at the apex, glabrous above, noticeably pubescent below only on the midrib; flowers all on the naked branches, in the axils of fallen leaves; peduncles very short, two to three flowered; pedicels stoutish,

about twice the length of the peduncle; flowers not seen; capsule small, cuboid, not exteeding four lines in diameter, merely notched or slightly lobed.

Type number 2636, collected at an elevation of 4000 feet, on Kaholuamano, above Waimea, Kauai, in damp woods, where it is not uncommon. Also collected on the ridge west of the Hanapepe river, at an elevation of 3500 feet; The specimens from the latter place have the leaves shorter, and consequently more obovate than those from Kaholuamano. There is also more pubescence on the under side, and the petioles are somewhat ciliate. The increase of pubescence is not constant, as it is more marked on the younger than on the older leaves.

Pelea oblongifolia A. GRAY, Bot. U. S. Expl. Exped. **15**: 343. 1854.

Specimens referable to this species, were collected on the plateau above Waimea, Kauai. It is a shrubby plant, with slender branches, and occurs as scattered individuals near the edge of the plateau.

October 2 (2869).

Pelea rotundifolia A. GRAY, Bot. U. S. Expl. Exped. **15**: 344, *pl. 37.* 1854.

This shrubby species is not uncommon at the type locality, "Oahu, mountains behind Honolulu," but only a few specimens were collected. Very few bushes were in either flower or fruit.

May 23 (2352).

Pelea sapotaefolia MANN, Proc. Bost. Soc. Nat. Hist. **10**: 312. 1866?

On the edge of the plateau above Waimea, Kauai, were collected specimens of the variety *beta* of Hillebrand. They have been compared with specimens in the Gray herbarium, and pronounced identical with specimens from both Mann & Brigham and Hillebrand. That this variety is specifically distinct from *P. sapotaefolia*, is pretty evident, but as my specimens have only young flowers, and as I have not seen specimens of *P sapotaefolia*, it is deemed best not to propose a specific name until better data are obtained. It is a small tree, freely and regularly branching above. The leaves are opposite, comparatively small, thin, broadly obovate, obtuse, abruptly narrowed below, on petioles of a half inch in length. The flowers appear to be smaller than those of *P. sapotaefolia*. One old capsule

was found on the tree, but unfortunately it dropped to the ground, and could not be found in the dense tangle of ferns and weeds which were growing at the foot of the tree. From what I recollect of it, it was entirely too deeply lobed to belong to the same section as *P. sapotaefolia.*

Pelea waialealae WAWRA, Flora, (II) **31**:108. 1873.

One of the smallest as well as handsomest species. It is a shrub, three or four feet high, and grows in clumps. The stems are slender, simple below, corymbosely branching above the branches ascending. The leaves can hardly be called "thin coriaceous," as Hillebrand translates it. Wawra and the writer appear to be the only botanists who have collected it. In the bog at the head of the Wahiawa river, Kauai, it is plentiful. Wawra collected his type on the "plateau des Waialeale, 2170."

August 21 (2733).

PLATYDESMA MANN, Proc. Bost. Soc. Nat. Hist. **10**: 317. 1866.

Platydesma campanulata MANN, Proc. Bost. Soc. Nat. Hist. **10**: 317. 1866.

Specimens were collected at the type locality, "Oahu, on the mountains behind Honolulu, at middle heights. M. & B. 94" Hillebrand's citation of the publication of this species is wrong, and his description is not good. My specimens do not work out well according to his description, but by using the original description of Mann, the plants are found to be quite identical.

May 28 (2373).

Platydesma rostrata HILLEBR. Fl. Haw. Is. 72. 1888.

On the ridge west of the Hanapepe river, Kauai, were collected two or three specimens which may belong to this species, unless they represent an undescribed one. Hillebrand's description of "leaves opposite, subsessile, linear-oblong, 12–16′ x 2–3′, of nearly even width from the suddenly rounded base to the bluntly acuminate apex, dark green, glabrous," applies tolerably well. The leaves are crowded on the ends of the branches, and the majority of them are inclined to be pointed. There is quite a difference though, in the size of the flowers. The description of *P. rostrata* calls for "petals 5″," while on my specimens they are an inch in length. No more than two or three flowers in a cluster were noticed, as opposed to "flowers 12–20

in shortly pedunculate cymose clusters." The type was collected on Kauai by Knudsen, probably on Halemanu, west of the Hanapepe river.

July 23 (2610a).

MELIACEAE.

MELIA L. Sp. Pl. 384. 1753.

Melia azederach L. Sp. Pl. 384. 1753.

A number of trees are found growing in Pauoa valley, Oahu, and also in Hanapepe valley, Kauai.

March to May (2006); original locality, "in Syria."

EUPHORBIACEAE.

ALEURITES Forst. Char. Gen. 3: *pl. 56.* 1776.

Aleurites moluccana (L.) Willd. Sp. Pl. 4: 590. 1805.

Jatropha moluccana L. Sp. Pl. Ed. 2, 1428. 1763.

This is the "Kukui," one of the largest, as well as the most common tree of the lower forest zone. In fact, it is the indicator of the upper limit of this zone, as it is never found above it. It is a large tree, with heavy, far spreading limbs. The light green leaves make it a very conspicuous object, especially as a number of trees always grow together, usually in ravines. It is a very useful tree to the natives of Polynesia, for, according to Hillebrand, "the nuts, strung together on sticks, served the natives for candles to light their houses, whence the English name Candle-nut tree. The gum which it exhudes seems also to have been in use. Of the acrid juice contained in the fleshy covering of the fruit, they prepared a black dye, which likewise served to tattoo their skins. The expressed oil of the nuts, besides being useful for burning in lamps, makes a good paint oil."

June 24 (2431); original locality, "in Moluccis, Zeylonia."

ANTIDESMA L. Sp. Pl. 1027. 1753.

Antidesma platyphyllum Mann, Proc. Am. Acad. 7: 202. 1867.

Hillebrand has two leaf characters which do not appear in the specimens of this collection. They are "punctato-papillose," and "youngest leaves speckled with a peltato-stellate

pubescence." Mann's original description says they are "glabris," and so I find them. Of the "paniculis ferrugineo-puberulis," I find traces only in the pistillate specimens, but the inflorescence of the staminate specimens is quite glabrous. A small tree, with grayish bark, collected on the ridge west of the Hanapepe river, Kauai, and also on the ridges above Waimea, between the forks of the Waimea river. It occurs on the islands of "Hawaii, Maui, Oahu, Kauai."

July to October (2497).

CLAOXYLON A. Juss. Euph. Tent. 43, *pl. 14.* 1824.

Claoxylon tomentosum (Hillebr.)

Claoxylon sandwicense var. *tomentosum* Hillebr. Fl. Haw. Is. 299. 1888.

These Kauai specimens are certainly distinct from *C. sandwicense.* The leaves are large, usually elliptical, and slightly notched at each end, or the younger ones obovate. They are very scabrous and papillose above, thickly pubescent beneath, especially along the veins, with appressed, curved, yellow hairs. Collected on the edge of the plateau above Waimea, Kauai. Knudsen's and Wawra's specimens, which are Hillebrand's type of variety *tomentosa*, came from the plateau of Halemanu, on the opposite side of the Waimea river.

October 15 (2878).

Claoxylon.

At the head of the valley opposite Gay & Robinson's Hanapepe valley house, island of Kauai, were collected specimens which perhaps are referable to *C. sandwicense*, which is described as follows by Hillebrand: "A small, soft wooded tree or shrub, 10–12 feet high, with pale, spreading branches, the youngest shoots tomentose but soon glabrate. Leaves obovate-oblong, 4–7′x2–3′, on petioles of 1–2′, shortly acuminate or obtuse, crenate serrate with callous uncinate teeth, contracted at the base, stiff membranaceous, lurid green, scabro-papillose but glabrate." Minor points of difference in my specimens are, shorter petioles, and leaves pubescent beneath with scattered white hairs. They are never acuminate, but rounded, or slightly pointed at the apex. The inflorescence seems to be injured, as the flowers are imperfect.

July 23 (2604).

EUPHORBIA L. Sp. Pl. 450. 1753.

Euphorbia atrococca n. sp. (*Plate L.*)

A small tree, about ten feet high, with brownish bark; freely branching above; secondary branches numerous, with moderately long internodes, glabrous; leaves numerous, but not crowded, narrowly obovate, the largest an inch and a half long, five-sixteenths of an inch wide, dull green, coriaceous, entire, midrib prominent, but veins obscure; petioles an eighth of an inch in length; stipules very short, broadly triangular, slightly fringed; flowers axillary, or a few terminal, numerous on short peduncles; capsule black or dark brown, pubescent, slightly keeled, on nodding stalks which are slightly longer than the pedicels; seeds pitted and rugose.

A species obviously related to *E. celastroides*, but the branches with shorter internodes, and the capsule dark and pubescent, and likewise keeled. It is never found below an elevation of 3000 feet, while *E. celastroides* is a plant of low elevations. The type is No. 2500, collected July 4th, on the ridge west of the Hanapepe river, Kauai, at an elevation of 300C feet.

On Kaholuamano, above Waimea, was collected a form, No. 2858, which is referable to this species. The leaves are fewer, shorter, broader, darker green, with veins more prominent, but it has the same dark, pubescent capsule. A well marked form, growing at an elevation of 4000 feet, near the edge of the woods.

Euphorbia celastroides Boiss. DC. Prodr. **15**: Part 2, 11. 1862.

A small tree, with short trunk; loosely branching. The secondary or young branches are stiff, with short internodes. These specimens, which answer very well to the description of *E. celastroides*, were collected on a sparsely wooded slope along the Hanapepe river, Kauai, at an elevation of 700 feet. Pretty conclusive evidence that it is the same as Boissier's plant, is the fact that the types were collected on Niihau and Kauai by Remy. Plants which occur on both Kauai and Niihau, must necessarily be only those which grow at low elevations, as Niihau nowhere has an elevation of more than 1000 feet. Nothing like it was seen on Oahu, although Hillebrand records it from the valley of Niu.

June 24 (2429).

Euphorbia clusiaefolia H. & A. Bot. Beechy, 95. 1832.

Hillebrand says that this species is an "erect shrub, 3–6 feet high, with stiff branches." He is said to have "visited all the larger islands, penetrating to the inmost recesses of their deepest and darkest ravines, and climbing to the summits of their loftiest mountains," yet it seems strange that he should make such an erroneous statement of a species which is common on the mountains back of Honolulu. It is by no means an erect shrub, but the soft branches are procumbent or reclining, and there is no trace of stiffness about them. To describe them as sarmentose would be much nearer the truth. Collected at 2500 feet elevation, on Konahuanui, Oahu. Also seen on Waiolani, at the same elevation.

May 23 (2345); from the original locality.

Euphorbia cordata Meyen, Reise, 2:150. 1843.

A low shrub, with short, gnarled stems and branches. The leaves are crowded, thick, orbicular. It appears to grow only in dry, hot places. Collected at Diamond Head, Oahu

March 28 (2019); from the original locality.

Euphorbia geniculata Ortega, Nov. Rar. Pl. Hort. Matr. Dec. 18. 1797.

Collected along the roadside in lower Nuuanu valley, Oahu, and in cultivated ground at Waimea, Kauai. It appears to be well established. Hillebrand says it appeared in gardens before his departure.

March to October (2035); original locality, tropical America.

Euphorbia multiformis Gaud.; H. & A. Bot. Beechy, 95. 1832.

That Gaudichaud had truly a plant of many forms in view, is evinced by these remarks by Hooker & Arnott: "If we be right in referring this to the plant alluded to by Gaudichaud, it must be a very variable species; that botanist remarking that in elevated situations it forms a small tree, the trunk of which is three or four inches in diameter; but, in descending is found smaller, till at last, in low cultivated places, it is only suffruticose, or even herbaceous." Hooker & Arnott give Gaudichaud the credit of the name, but say "absque descriptione," which fact simplifies matters very much, for there can be no doubt about the plant which they describe and credit to Gaudichaud. Their plant came from Oahu, and apparently none of the other

forms occur there, except *E. celastroides*, recorded from the remote valley of Niu, into which it is hardly possible that Lay & Coolie penetrated. It is plentiful about the rocky slopes of Nuuanu Pali, and here is where Lay & Coolie probably collected their specimens. As described by Hillebrand, it is a "glabrous shrub, 2–5 feet high."

April 23 (2199).

Euphorbia pilulifera L. Sp. Pl. 454. 1753.

An introduced species, which is very common in the "lowland zone." It occurs as a dwarf in the hot and dry regions about Salt Lake and Diamond Head, and is also found growing luxuriantly in moist, cultivated ground.

March to August (1980); original locality, "in India."

Euphorbia rivularis n. sp. (*Plate LI.*)

A shrub, five or six feet high, simple below, with a stem almost an inch in diameter; branches loose, spreading, somewhat drooping, with short internodes; leaves regularly opposite, standing at right angles to the branch, except the ultimate ones, which extend forward, oblong, usually slightly curved, two inches long, six sixteenths of an inch wide, glabrous, pale green above, lighter beneath, blunt and rounded at the end and sometimes slightly retuse, somewhat narrowed and unequal sided at the base; veins not prominent, at acute angles to the midrib; petioles an eighth of an inch in length; stipules low, broadly triangular or lunate, not fringed; inflorescence several flowered; flowers on slender, angled pedicels; capsule very short stalked, erect, glabrous.

The type is No. 2441, collected on the banks of the Hanapepe river, Kauai, at an elevation of about 600 feet. A species apparently related to *E. celastroides*, but of a very different habit. It is much smaller, more simple, and grows on rocks overhanging the river. It is unique on account of the long, regularly opposite leaves.

Euphorbia sparsiflora n. sp. (*Plate LII.*)

A glabrous shrub, ten inches to two feet high; stems slender, branched, the branches ascending; bark grayish, or light brown; leaves obovate, evenly narrowed to a wedge-shaped base, rounded and blunt at the end, an inch or less in length, on short petioles, a sixteenth of an inch in length, veins not conspicuous; stipules low, broadly ovate, somewhat fringed; flowers few, solitary in the upper axils; pedicels very short and slender; capsule smooth, nodding, on a short, slender stalk.

The type is No. 2699, collected at an elevation of 3000 feet, in the bog at the head of the Wahiawa river, Kauai. In some respects it resembles *E. multiformis*, but appears to be distinct. The erect stems and branches are often partly covered with moss and other swamp vegetation. Specimens were distributed under the name of *Euphorbia palustris*, but as that name is preoccupied, the appropriate one of *sparsiflora* is now substituted.

PHYLLANTHUS L. Sp. Pl. 981. 1753.

Phyllanthus sandwicensis MUELL. Arg. Linnaea, **32**: 31. 1863.

Not uncommon on the grassy slopes of the Pali, Oahu. It is usually decumbent, due, no doubt, to the high winds which are prevalent there. Also collected on the ridge west of the Hanapepe river, Kauai. Here it was growing in the woods, at an elevation of 3000 feet. It is a shrub, ten inches to two feet high. Hillebrand cites this species as published in DC. Prodromus, 15: Part 2, 389.

April to August (2196).

ILICACEAE.

BYRONIA ENDL. Ann. Wien. Mus. **1**: 184. 1836.

Byronia anomala (H. & A.)

Ilex ? anomala H. & A. Bot. Beechy, 111, *pl. 25.* 1832.

Reference to the plate of *Ilex ? anomala*, in the Botany Beechy, and to that of *Byronia sandwicensis* in the atlas of the Botany of the U. S. Exploring Expedition, shows that two very distinct plants are figured. The plant here taken up is the only form found on Oahu, and on that island is where Lay & Coolie obtained the type of Hooker & Arnott's species. I do not know whether Endlicher based his *Byronia sandwiscensis* upon the same plant or not, but in either case, the specific name of *sandwicensis* cannot be applied to this Oahu plant, to which the name *anomala* belongs. It is shrubby rather than arborescent, with short crowded branches. The leaves are thick, broadly obovate-spatulate, or stout, margined petioles, and crowded near the ends of the branches. The inflorescence is practically terminal and compact Collected on the slopes of Konahuanui, Oahu, at elevations of 2000 to 3000 feet.

May to October (2242); from the original locality.

Byronia sandwicensis ENDL. Ann. Mus. Wien. **1**: 184. 1836.

On the ridge west of the Hanapepe river, Kauai, at an elevation of 3000 feet, specimens were collected which seem to be identical with those of the U. S. Exploring Expedition, plate 26. They were obtained from a small much branched tree, which differs from *B. anomala* in being more branched, the leaves smaller and more scattered, and the inflorescence is very different. Instead of being almost terminal and ascending, it is axillary, the peduncles and pedicels more widely spreading, and not so stout, The flowers are amaller, and the fruit is narrower and longer.

June 28 (2455).

Byronia sandwicensis ENDL. var.

This form is hardly separable from the above, yet is constant enough in localities where it occurs. It differs in being less branched, has more crowded leaves nearly elliptical in outline, instead of obovate, and a more copious inflorescence. In the bog at the head of the Wahiawa river, Kauai, it is found as a low shrub, with ascending branches, while above Waimea, on the plateau, it is a larger bush, with more spreading branches.

August to October (2735).

CELASTRACEAE.

PERROTTETIA H. B. K. Nov. Gen. et Sp. **7**: 73, *pl. 622.* 1825.

Perrottetia sandwicensis A. GRAY, Bot. U. S. Expl. Exped. **15**: 291, *pl. 24.* 1854.

Collected at the type locality, "on mountains behind Honolulu, Oahu." It is common on the lower slopes of Konahuanui, and also on the island of Kauai. On the latter island it ranges as high as 4000 feet, but is also found in the lower woods along the Hanapepe river. A small tree, with light green, red-veined shining leaves.

October 29 (2908).

SAPINDACEAE.

CARDIOSPERMUM L. Sp. Pl. 366. 1753.

Cardiospermum microcarpum H. B. K. Nov. Gen. et Sp. 5:104. 1821.

Collected on grassy slopes at an elevation of about 500 feet, in Hanapepe valley, Kauai. All of the plants observed belong to this species, which Hillebrand has united with *C. halicacabum.*

July 8 (2529); original locality, "in humidis prope S. Fernando de Atabapo (Missiones des Orinoco)."

DODONAEA L. Systema, Ed. 13, 299. 1774.

Dodonaea eriocarpa SMITH, Rees Cycl. 12.

On the bare slopes between the forks of the Waimea river, Kauai, is a very common plant, which is referable to this species. The bushes vary in size from two to four feet, with ascending branches. The leaves are thick, elliptical-lanceolate, and more or less pubescent on both sides. Notwithstanding the abundance of bushes, only a few of them were in flower, and so far as can be ascertained without fruit, they answer to the description of *D. eriocarpa,* as given by Hillebrand.

September 30 (2846).

Dodonaea viscosa L. Systema, Ed. 13, 299. 1774.

As this species is now known, it seems likely that it is an aggregate of several good species. This particular form, which was collected above Waimea, Kauai, at elevations of 3000 to 4000 feet, is a tree fifteen feet high, with slender, wide-spreading branches. The leaves are two to four inches long, elliptical-lanceolate, on short petioles, thin, shining, and with margins somewhat undulate. The young leaves are viscid.

October 8 (2871).

RHAMNACEAE.

ALPHITONIA REISSEK.; ENDL. Gen. Pl. 1098. 1840.

Alphitonia ponderosa HILLEBR. Fl. Haw. Is. 81. 1888.

Alphitonia excelsa MANN, Proc. Am. Acad. 7:161. 1867, not Reissek.

Speaking of this species, Hillebrand says: "Waimea, Kauai, where it attains a greater height than any other tree on that

island (Knudsen)." It is a conspicuous object in the forest on account of the dense brick-red tomentum, which covers the under sides of the young leaves, as well as the flower buds The mature leaves are rather thick, dark green and shining above, with prominent veins, while below they are covered with short, white hairs, which contain a trace of red along the midrib. It is common on the edge of the plateau above Waimea, Kauai, but is by no means the largest tree in that vicinity, as several other species attain a greater height, as well as a greater thickness of trunk.

August 22 (2748).

ELAEOCARPACEAE.

ELAEOCARPUS L. Sp. Pl. 515. 1753.

Elaeocarpus bifidus H. & A. Bot Beechy, 110, *pl. 24.* 1832.

A common tree in the lower and middle forest regions of Oahu and Kauai. On Kauai, it is found from the lower forest limit in Hanapepe valley, to an elevation of 4000 feet above Waimea. The type was collected by Lay & Coolie on the mountains back of Honolulu, where it is abundant.

May to July (2374).

MALVACEAE.

HIBISCUS L. Sp. Pl. 693. 1753.

Hibiscus abelmoschus L. Sp. Pl. 696. 1753.

The entire leaved form of this species was collected in Hanapepe valley, Kauai, a short distance below the falls. There is no record of its occurrence on the Islands. How it happened to be brought into such an out of the way place is not known, although the irrigating ditch which leads to the Makaweli plantations, some six or eight miles below, may have something to do with its dispersal. It was found at only one place, in a thick growth of grass, ferns, and other vegetation, under and near the flume where the ditch crosses a little ravine. The seeds must have been carried there in some way while the ditch was being constructed, or during repairs. The long hairs on the herbaceous stems are very sharp, having somewhat the nature of those on nettle plants.

July to October (2553); original locality, "in Indiis."

Hibiscus arnottianus A. GRAY. Bot. U. S. Expl. Exped. **15**: 176. 1854.

Gray describes this as "a shrubby species, several feet in height, glabrous throughout, especially the leaves," and says it was collected "on the Kaala mountains behind Honolulu, Oahu." This is a very strange statement, as Mt. Kaala is more than twenty miles northwest of Honolulu. On the heights of Pauoa, just back of Honolulu, where very likely the specimens of Lay & Coolie, as well as those of the Exploring Expedition were collected, I saw what passes for this species in Hillebrand's Flora. The time was early in November, at the end of the flowering season, when nearly all of the flowers had fallen, and were rotting on the ground beneath the trees. It is a small tree, or large shrub, with a short trunk, which branches freely. The leaves are broadly ovate, entire, obtuse, or slightly pointed, and rather prominently five nerved. Instead of being smooth, the growing parts, at least, are pubescent with fulvous, stellate hairs. The calyx is broadly cylindrical, of an even width throughout, pubescent. The pubescence is of two kinds, some of the hairs being in short stellate tufts, while others are several times longer, and more like spines. The calyx lobes are short, slender pointed, from a broad triangular base. The seven involucral bracts are more than half the length of the calyx. The large white flowers are decidedly pubescent on the outside. The only thing about this plant, so far as I can find, which answers to the description of *H. arnottianus* by either Gray or Hillebrand, is the long staminal column. Gray's type is a specimen collected by Diell, presumably at Byron's Bay, island of Hawaii, and the flowers are said to be red. Judging from the literature at hand, Gray, in his description, must have confused this white flowered Oahu form with the red flowered one since described by Hillebrand as *Hibiscus Kokio.* However matters may be, the type is the plant collected by Diell, and it now seems as though the Oahu plant is an undescribed species.

Hibiscus Waimeae n. sp. *(Plate LIII.)*

A tree, twenty or twenty-five feet high, with close gray bark; trunk with a diameter of six inches or more, branched only near the top; branches far spreading and slightly drooping; leaves almost orbicular, with an average diameter of two inches, pale green, crenate, pubescent on both sides, that of the upper side scattered and short, that of the lower side very close and thick, velvety to the touch; petioles pubescent, about half the

length of the leaves; stipules small, subulate; flowers axillary, near the ends of the branches, large, white, or tinged with pink, on pubescent pedicels, which are jointed near the end; involucral bracts seven in number, linear-lanceolate, a half inch in length; calyx broadly tubular, somewhat inflated above, an inch and a half in length, short pubescent on the outside, wooly within, the teeth ovate-lanceolate, a half inch in length; petals five to six inches in length, including an exserted claw of two inches, one and a half to two inches wide, prominently veined, pubescent on the outside; staminal column rather stout, long exserted, red; stamens numerous, filaments slender, an inch in length, anthers red; styles five, slender, ascending, the stigmas capitate, red.

A well marked species, united by Hillebrand with the Oahu plant which he calls *Hibiscus arnottianus.* Although closely related to that plant, it differs in numerous particulars. It is a much larger tree, with smaller leaves, of a different shape and texture. The pubescence is somewhat stellate, as indeed it seems to be in all of the Hawaiian plants. The type is No. 2785, collected at the base of the plateau above Waimea, Kauai, at an elevation of 3000 feet.

Hibiscus youngianus GAUD.; H. & A. Bot. Beechy. 79. 1832.

This species is mentioned by Gaudichaud, in Bot. Voy. Uranie, but is not described. The first description appears to be by Hooker & Arnott, who credit the species to Gaudichaud. Its natural habitat is in the marshes at no great distance from the coast, and is described by Hillebrand as "an erect, sparingly branched undershrub, 2–3 feet high." Specimens were collected in upper Pauoa valley, Oahu, growing in a little ravine, where it attained a height of ten feet, bearing a few branches near the top. It was also seen as a bush five or six feet high, in marshes near Pearl City. It is found only on Oahu.

April to June (2007).

MALVASTRUM A. GRAY. Mem. Am. Acad. (II) **4**: 21. 1848.

Malvastrum americanum (L.) TORR. Bot. Mex. Bound. Surv. 38. 1859.

Malva americana L. Sp. Pl. 687. 1753.

Malvastrum tricuspidatum A. GRAY, Pl. Wright. **1**: 16. 1852.

This is one of the most common weeds about dwellings and in cultivated ground. It was seen on both Oahu and Kauai.

April to August (2136); original locality, "in America."

PARITIUM A. JUSS.; St. HIL. Fl. Bras. Mer. 1:255. 1827.

Paritium tiliaceum (L.) St. HIL. Fl. Bras. Mer. 1:256. 1827.

Hibiscus tiliaceus L. Sp. Pl. 694. 1753.

"Hau", tree, is one of the names which a stranger first hears at Honolulu, when native plants are mentioned. The growth of this plant is rather peculiar. Rarely, at least when growing wild, is it found as a tree with large trunk and ascending branches. Its usual manner of growth is much like that of the banyan tree. The main branches perhaps ascend for a short distance, then turn off at a right angle, and soon descend to the ground, to creep along for some distance, and then again ascend, or send off smaller branches. The general impression which it gives, is that of a tangle of vine-like branches, with no apparent beginning or end. The flowers are large, and look much like those of a *Hibiscus*, and are bright yellow, with a dark brown centre. When in full bloom, a Hau thicket is a beautiful sight. The species is common in the valleys and on open slopes on both Oahu and Kauai.

April to July (2203); original locality, "in Indiis."

SIDA L. Sp. Pl. 683 1753.

Sida acuta BURM. f. Fl. Ind. 147. 1768.

Sida carpinifolia L. f. Suppl. 307. 1881, fide Index Kewensis.

In Hanapepe valley, Kauai, grows a plant referable to this species. From the majority of the specimens of *S. acuta* in the herbarium of Columbia University, it differs in having shorter pedicels, and more pubescence on the ends of the branches. It is very abundant along the river banks from Gay & Robinson's house to the falls, and apparently extends beyond, along the main branch of the river. It is a rather stiff plant, one to two feet high, with woody stem and branches.

June 24 (2424).

Sida angustifolia MILL. Gard. Dict. Ed. 8, No. 3. 1762.

This plant is called *Sida spinosa* by Hillebrand, who says: "Near Honolulu, at the base of Punchbowl hill." It is still very abundant about Punchbowl, but has spread considerably, and now is found in many localities about Honolulu.

April 25 (2200).

Sida fallax WALP. Nov. Act. Nat. Cur. **19**: Suppl. 1, 306. 1843.

A species which is common on the lee side of Oahu, especially about Diamond Head, where it was collected by the botanists of the U. S. Exploring Expedition. In none of the descriptions of *Sida*, so far as I have observed, is there reference to the unequal sided petals which is so characteristic of the Hawaiian plants. They are erosely notched, the sinus being quite broad. The flowers are often over an inch in diameter, orange yellow. The leaf forms are variable, though generally broadly ovate, and the end either pointed or rounded. The canescent pubescence is variable too, but always present, usually decidedly so.

Sida meyeniana WALP. Nov. Act. Nat. Cur. **19**: Suppl. 1, 307. 1843.

Plants referable to this species were noticed at various places in Hanapepe valley, Kauai (2717). It is a slender bush, six to eight feet high, with large, orange-colored flowers, and light green leaves. The leaves are broadly ovate, rather large, unequally serrate, grayish underneath with very short, stellate hairs. The calyx lobes are ovate, acute, marked for half their length by a broad white rib, and are somewhat pubescent on the outside, with the inside of the tips wooly. The young stems, petioles, and pedicels, are covered with bunches of stellate hairs.

Another very different form, or rather two forms, is No. 2197. The first one was collected at the Nuuanu Pali, Oahu. It is a low, prostrate, much branched shrub, with small, broadly ovate or almost orbicular leaves, which are bright green on both sides, and only the younger ones pubescent. Later, specimens were collected in Waialae valley, and included under this number. These specimens were from an erect, branching bush, four or five feet high. The leaves are also bright green on both sides, broadly lanceolate, with a base somewhat cuneate. None of these specimens agree very well with either Gray or Hillebrand's descriptions of *Sida meyeniana*, nor does there seem to be any other described Hawaiian species to which they can be referred.

Sida rhombifolia L. Sp. Pl. 684. 1753.

Common about Honolulu, in waste ground. It also occurs on Tantalus, in the forest. The flowers are of medium size, pale yellow.

March to June (1973, 2294); original locality, "in India utraque."

STERCULIACEAE.

WALTHERIA L. Sp. Pl. 673. 1753.

Waltheria americana L. Sp. Pl. 673. 1753.

Common on dry slopes of the lee side of Oahu. Also found on Kauai.

March 25 (2085); original localities, "in Bahama, Barbiches, Surinamo.

TILIACEAE.

TRIUMFETTA L. Sp. Pl. 444. 1753.

Triumfetta

An undetermined species of this genus was collected in lower Nuuanu valley, Oahu, growing on the outskirts of Honolulu. The stout stem is woody, three or four feet high, much branched. The leaves are round-ovate, green above, and slightly pubescent, white woolly beneath, with short hairs. The small fruit is covered with echinate prickles.

May 10 (2293).

BIXACEAE.

BIXA L. Sp. Pl. 512. 1753.

Bixa orellana L. Sp. Pl. 512. 1753.

Scattered trees of this species are found in Hanapepe valley, Kauai. It is a low tree, with thick, spreading branches, and when covered with its pink flowers, presents a pleasing sight. Collected in fruit only.

July 1 (2477); original locality, "in America calidiore."

MYROXYLON Forst. Char. Gen. 125. 1776.

[**Xylosma** Forst. f. Prodr. 72. 1786.

Myroxylon hawaiiense (Seem.) Kuntze, Rev. Gen. Pl. 44. 1891.

Xylosma hawaiiense Seem. Fl. Vit. 7. 1865-68.

A large tree, with heavy branches, and thick, leathery, ovate leaves. Flowering specimens were collected on the ridge west of the Hanapepe river, Kauai, at an elevation of 3000 feet. It is found only on the islands of Oahu and Kauai.

July 23 (2611).

TERNSTROEMIACEAE.

EURYA Thunb. Nov. Gen. 67. 1783.

Eurya sandwicensis A. Gray, Bot. U. S. Expl. Exped. **15**: 209. 1854.

Collected at the type locality, "mountains behind the town of Honolulu." One form (2240), which was distributed as *Eurya sessilifolia*, n. sp., is apparently only a sessile leaved form, and is mentioned by Gray in the original description. It grew near the summit of Konahuanui, and has larger, more crowded, sessile leaves, which are clasping at the base. No. 2311, the normal form with smaller, petioled leaves, was collected on the same mountain, but at much lower elevations—about 2000 feet.

VIOLACEAE.

ISODENDRION A. Gray, Bot. U. S. Expl. Exped. 15: 92. 1854.

Isodendrion subsessilifolium n. sp. (*Plate LIV.*)

A slender, wand-like shrub, two to six feet high, simple, or sometimes sparingly branched, the branches ascending; glabrous, bark grayish; leaves alternate, scattered along the upper part of the stem, on very short petioles, oblong-obovate, somewhat pointed, two to three and a half inches long, an inch to an inch and a half wide, glabrous on both sides, the margins undulate, or obscurely serrate; stipules small, persistent, narrowly lanceolate, from a broad base, furnished with a prominent midrib; flowers axillary, solitary, on very short pedicels, which are subtended by a cluster of short bracts; calyx short, one-fourth the length of the corolla, its lobes lanceolate, con-

vex, keeled, slightly ciliate; corolla three-eighths of an inch long, streaked with purple; petals connivent for nearly their entire length, forming a tube, oblong, blunt, the ends somewhat dilated, twisted and recurved; stamens five, short, barely exceeding the ovary, filaments flat, slightly expanded above, anthers broad, with short, curved appendages at the base; style the length of the corolla tube, almost straight, slightly thickened at the apex, stigma minute.

The type is No. 2828, collected above Waimea, Kauai, at an elevation of 2000 feet. I was growing in a ravine between the forks of the Waimea river. Hillebrand seems to have had specimens of this species, collected by Knudsen, probably on the west side of the Waimea river. He referred them, however, to *Isodendrion longifolium*, specimens of which I have seen in the herbarium of Columbia University, and which is a very different plant, as evinced by the specimens mentioned above, and by the plate, in the atlas of the Botany of the U. S. Exploring Expedition. Plate LIV shows a flowering stem, and a flower and stamen enlarged.

VIOLA L. Sp. Pl. 933. 1753.

Viola chamissoniana GINGINS, Linnaea, **1**: 408. 1826.

Hillebrand records a variety of this species from Kauai, which has "young shoots and inflorescence puberulous." In specimens collected along the edge of the plateau above Waimea, the leaves are pubescent underneath, even the older ones. It is a spreading bush, three or four feet high, with pale violet flowers. The type was collected by Chamisso, on Oahu, in 1807.

October 12 (2880).

Viola kauaensis A. GRAY, Bot. U. S. Expl. Exped. **15**: 85. 1854.

These specimens differ considerably from Gray's original description, who, it seems, did not have the early, large flowered form. He says: "The flowers of the specimens are probably late ones, with the petals smaller than when fully developed, as they are not quite so long as the calyx. * * * What strengthens the suspicion that these are only such precociously fertilized and cryptopetalous flowers as produced by many violets, is that the stamens are scarcely shorter than the petals." The description calls for "peduncles 1½ to 2 inches long, nearly the length of the petioles, glabrous, furnished

with a pair of linear lanceolate slightly glanduliferous bractlets a little below the flower." The peduncles are several times longer than the stem leaves in my specimens, and the bractlets are situated about an inch below the flowers. The "caulibus gracilbus repentibus," is not near so good as Hillebrand's description: "Rhizome creeping, rather thick, 2–3″, scaly near the apex with obtuse stipules, and bearing (besides the remnants of older ones) one or two slender scapes 4–8′ in length, with 1 internode and a single leaf and flower, or with 2 internodes, and a second leaf and flower." At the top of the rhizome, and springing from the same place as the scape, are usually several leaves with very long petioles. The sepals are scarious margined, and the petals notched. The following note by Hillebrand is also well borne out: "Knudsen writes me that the stem is neither creeping nor trailing, but always erect." Collected in the bog at the head of the Wahiawa river, Kauai, at an elevation of 3000 feet. The type specimens from which Gray described the plant, came from the great bog of "Lehua mankanoe," on the plateau above Waimea.

August 12 (2701).

PASSIFLORACEAE.

PASSIFLORA L. Sp. Pl. 955. 1753.

Passiflora edulis SIMS, Bot. Mag. *pl. 1989.* 1818.

Although an introduced plant, this species has all the appearance of being native on Kauai. Specimens were collected in the depths of the forest, on the ridge west of the Hanapepe river, and it was seen at other equally out of the way places. The acid, juicy fruit is very refreshing. It is about the size and shape of a hen's egg, purple when ripe. It is said to have been described from specimens grown from seeds received from Portugal.

July 11 (2542).

PAPAYACEAE.

CARICA L. Sp. Pl. 1036. 1753.

Carica papaya L. Sp. Pl. 1036. 1753.

The "Papaya" has become well established in Hanapepe valley, Kauai. The fruit is yellow when ripe, and in shape and size very much like that of the "egg plant" commonly

found in our markets. The female flowers, and consequently the fruit also, are sessile and clustered at the base of the lowest leaves, while the male flowers are on long peduncles which spring from the axils of the leaves above. It has a palm-like growth, the soft, scarcely woody trunk often six inches in diameter, and thickly studded with the scars of fallen leaves. The milky juice is said to possess properties similar to pepsin.

July to October (2618); original locality "in Indiis."

THYMELAECEAE.

DIPLOMORPHA MEISSNER, Denkschr. Regensb. Ges. **3**:289. 1841.

[**Wikstroemia** ENDL. Prodr. Fl. Norf. 47. 1833, not Spreng, 1821.]

Diplomorpha elongata (A. Gray).

Wikstroemia elongata A. GRAY, Seem. Journ. Bot. **3**: 303. 1865.

This species is common in the forests above Hanapepe valley, Kauai, and exceedingly variable. Hillebrand describes it as a "sparingly branching shrub, 4–6 feet high," and says it grows "in the lower woods of Kauai, Lanai, Maui." Near the lower edge of the woods it is usually of a shrubby nature, but at elevations of 3000 feet and more, in the depths of the forest, where it is also plentiful, it is arborescent. Here it is a small tree, with a symmetrically branched top. The leaves in these arborescent forms are smaller and narrower than in the shrubby forms of lower elevations.

July (2535, 2631).

Diplomorpha elongata recurva (HILLEBR.)

Wikstroemia elongata var. *recurva* HILLEBR. Fl. Haw. Is. 386. 1888.

Among specimens sent to the Gray Herbarium, at Harvard University for verification, No. 2581 was pronounced to be the variety *recurva* of Hillebrand, as it matched specimens from Hillebrand and Mann & Brigham. It seems to differ only slightly from the other specimens referred to *elongata*, and is hardly more than an individual variation. The specimens were taken from a large bush on the lower edge of the forest, on the ridge west of the Hanapepe river.

No. 2545, collected on the same ridge, but higher, could not be matched at Harvard, and I had decided to describe it as a

new species, under the name of *longepedunculata*, but it answers much better to Hillebrand's description of variety *recurva*, than does No. 2581. The following is his description: "Spikes on peduncles of 3-10'', much lengthening with growth, and strongly recurved, the slender, almost filiform and glabrous rachis often attaining a length of 2½ inches, covered with persistent pedicels, but the flowers confined to the apex." My specimens fit this description perfectly, many of the peduncles being over two inches in length, and strongly recurved. It was found in a single restricted area, but was plentiful there. The bushes were small and slender, only two or three feet high.

Diplomorpha oahuensis (A. GRAY).

> *Wikstroemia foetida* var. *Oahuensis* A. GRAY, Seem. Journ. Bot. **3**: 302. 1865.

The uniting of this with *Wikstroemia foetida*, a species not found nearer than Samoa, is not at all satisfactory, especially since the other Hawaiian species are endemic. Another reason for considering it as specifically distinct, is that it is a variable plant as it occurs in the Hawaiian Islands, No. 2211, collected on the lower slopes of Konahuanui, back of Honolulu, Oahu, is similar to specimens collected by the botanists of the Exploring Expedition, except that the leaves are broader. The type is Remy, 223, collected on Oahu. Hillebrand arranges the species under two heads, those with large leaves, and those with small leaves. Under the large leaved group we have two species, *oahuensis* and *elongata*, with slender, glabrate spikes. By following this classification, one has the choice of referring all large leaved forms with a smooth inflorescence to one or the other of these two species, or describing new species. The former plan is not satisfactory, and the latter is not a safe one, unless the person who follows it has had an opportunity to study all of the forms in the living state.

In the bog at the head of the Wahiawa river, Kauai, was collected a form (2737), which is referable to *oahuensis*, of which species it has the leaf characters, but according to Hillebrand's descriptions, has the flower characters of *elongata*, for the scales are only half the length of the ovary, which is thick, with a thick nearly sessile stigma. It is a low bush, the branches usually decumbent and resting on the wet moss and hepatics which are found nearly everywhere on the surface of the bog. Sometimes the bushes are erect, about two feet in height. Hillebrand gives the habitat of *oahuensis* as "in valleys and along the lower skirts of the woods on all islands."

Another troublesome member is No. 2780, collected on the plateau above Waimea, at an elevation of 4000 feet. It is a small tree, growing well back in the forest, on the edge of a ravine. The leaves are usually over two inches in length, elliptical-ovate, thick and leathery, very glaucous above, and pale green underneath. The fruit is very large, almost a half inch in length, and a quarter inch in diameter at the thickest part. It is referable rather to *oahuensis* than to *elongata*, but is probably distinct from either.

The following are the remaining Hawaiian species:

Diplomorpha bicornuta (HILLEBR.)

Wikstroemia bicornuta HILLEBR. Fl. Haw. Is. 387. 1888.

Diplomorpha buxifolia (A. GRAY)

Wikstroemia buxifolia A. GRAY, Seem. Journ. Bot. **3**: 304. 1865.

Diplomorpha hanalei (WAWRA)

Wikstroemia hanalei WAWRA, Flora, (II) **33**: 185. 1875.

Diplomorpha phillyraefolia (A. GRAY)

Wikstroemia phyllreaefolia A. GRAY, Seem. Journ. Bot. **3**: 304. 1865.

Diplomorpha sandwicensis (MEISNER)

Wikstroemia sandwicensis MEISNER, DC. Prodr. **14**: 545. 1856.

Diplomorpha uva-ursi (A. GRAY)

Wikstroemia uva-ursi A. GRAY, Seem. Journ. Bot. **3**: 304. 1865.

Diplomorpha villosa (HILLEBR.)

Wikstroemia villosa HILLEBR. Fl. Haw. Is. 386. 1888.

LYTHRACEAE.

LYTHRUM L. Sp. Pl. 446. 1753.

Lythrum maritimum H. B. K. Nov. Gen. et Sp. **6**: 194. 1823.

This species, if indeed the Hawaiian plant is *L. maritimum*, is usually found in the lower forest, or on the outskirts, in damp, grassy places. Collected on the heights of Pauoa, back of Honolulu, at elevations of 800 to 2000 feet.

May (2329); original locality, "in litore Oceani Pacifici, prope Patibilicam Peruvianorum."

PARSONSIA P. Br. Civ. and Nat. Hist. Jam. 199, 1756.

[**Cuphea** P. Br. Civ. and Nat. Hist. Jam. 216. 1756.]

Parsonsia pinto (Vand.)

Balsamona pinto Vand. Fl. Lus. 30, *pl. 4.* 1788.
Cuphea balsamona C. & S. Linnaea, **2**: 363. 1827.

This species, which Hillebrand refers to the very different *Cuphea hyssopifolia*, is very common near Honolulu in damp places, and also in the lower forests. It is common, too, on Kauai. If "of early accidental introduction," it has become widely spread on several of the islands of the group.

April to October (2004).

MYRTACEAE.

EUGENIA L. Sp. Pl. 470. 1753.

Eugenia malaccensis L. Sp. Pl. 470. 1753.

The "Ohia," or "mountain apple," is now rare on Oahu, at least near Honolulu, but is plentiful in Hanapepe valley, Kauai. The pear-shaped, bright red-purple fruit is very juicy. The red-purple flowers are abundant, and grow in clusters directly on the large branches and on the trunk, instead of on the ends of young branches.

June 29 (2468); original locality, "in Indiis."

Eugenia (Syzygium) sandwicensis A. Gray, Bot. U. S. Expl. Exped. **15**: 519. 1854.

This is certainly generically distinct from *Eugenia*, the type of which is *E. malaccensis*, if we take the plant first mentioned in the Species Plantarum as the type of the genus. The "Ohia ha," as this species is called by the natives, has both fruit and flower characters different from *Eugenia malaccensis*. Instead of stamens many times longer than the petals, they are only slightly longer. In the description Gray says: "Berry globular, as large as a cherry, containing one or two seeds which, as likewise the embryo, accord with those of *Eugenia*. * * * This is one of the connecting forms between *Eugenia*, *Acmena*, and *Syzygium*, with the habit rather of the latter." The fruit has a different shape from that of *Eugenia malaccensis*, for, instead of there being a cavity in which the round, chaff-covered seeds fit loosely, the thin, fleshy covering fits closely around the smooth, gray seeds. Collected at the original locality, "on the mountains behind Honolulu," and the speci-

mens appear to be typical, but they were from small shrubs, instead of a "tree twenty feet high." Specimens from Kauai are very different, and probably are specifically distinct. On that island it is one of the largest forest trees, and occurs at elevations of 2500 to 4000 feet. The leaves are much smaller, elliptical-lanceolate. I will not attempt to transfer this species to a different genus at present, for *Syzygium* GAERTN. is not applicable on account of the earlier *Suzygium* of Peter Browne, which is a synonym of *Chytraculia*, Peter Browne.

June to November (2241).

NANI(A) ADANS. Fam. Pl. **2**: 88. 1763.

[**Metrosideros** BANKS; GAERTN. Fr. & Sem. **1**: 170, *pl. 34.* 1788.]

Intergrading as do the Hawaiian forms of the "Lehua," the botanist who carefully studies them in the field, certaily cannot include them all under one polymorphous species. This latter plan is an easy way, and students of the Hawaiian flora have thus far contented themselves by following it, whether it was scientific or not. Even by eliminating the extreme forms, there are troublesome intergrading individuals which must be placed somewhere, and the best way seems to be to refer them to the extremes with which they have the most points in common, even theugh they do not agree well in some particulars. Primarily, there are two divisions, based on the shape of the leaves. The first, of which *N. polymorpha* is the type, has orbicular or broadly ovate leaves. The second has lanceolate leaves, and its type is *N. tremuloides*, which represents the extreme lanceolate form. Until opportunity for more extended study offers, the following provisional treatment is given:

Leaves broadly ovate or orbicular	
Calyx white wooly	
Small tree, leaves small, wooly underneath, not rugose above.	*N. polymorpha.*
Small tree, leaves small, wooly underneath, rugose.	*N. rugosa.*
Bush, leaves large, glabrous	*N. pumila.*
Calyx glabrous or pubescent, but not wooly	
Leaves large, glabrous, petioles long	*N. macropus.*
Leaves small, glabrous, petioles short	*N. glabrifolia.*
Leaves neither broadly ovate nor orbicular	
Leaves pointed at both ends, calyx glabrous	*N. tremuloides.*
Leaves broader, rounded at one or both ends, calyx tomentose or glabrate	*N. lutea.*

Nani(a) polymorpha (GAUD.)

Metrosideros polymorpha GAUD. Bot. Voy. Uranie, *pl. 108, 109.* 1830.

This is said by some botanists to be the same as *Metrosideros villosa,* but it is not likely that precisely the same forms of a genus which is so variable on the Hawaiian group, occur also on islands so far removed as the Society and Viti groups. We have conclusive evidence too, in Hillebrand's remarks, that they are not the same, for he says : "According to Seeman, all Hawaiian forms, except the extreme tomentose with rounded leaves, are represented in the Society Islands." This extreme tomentose form with round leaves, is exactly the var. *a,* the type, if there is any, of *Metrosideros polymorpha.* Hillebrand, who, during his residence of 20 years on the Islands, had an opportunity of bringing this chaotic genus into order, appears to have merely followed the treatment of Gray and Seeman, without attempting to do anything original. Gray had specimens of this species from "Oahu, on the mountains behind Honolulu." It is still found there, but only as scattered trees, at elevations of 1500 to 1800 feet. Although only a small tree, ten to fifteen feet high, it is a conspicuous object at almost any time of the year. The young leaves, which are closely crowded on the ends of the branches, are of a purplish hue, while before flowering the densely white tomentose buds are almost as showy as the open flowers with their crimson stamens.

May 28 (2375).

Nani(a) rugosa (A. GRAY) KUNTZE, Rev. Gen. Pl. 242. 1891.

Metrosideros rugosa A. GRAY, Bot. U. S. Expl. Exped. **15**: 561, *pl. 69 B.* 1854.

This species I did not collect, but have seen specimens of it in the herbarium of Columbia University, and in the Bernice Pauahi Bishop Museum, at Honolulu. In general appearance it is much like *N. polymorpha,* but quite distinct. It also came from the "mountains behind Honolulu."

Nani(a) pumila n. sp. *(Plate LV.)*

A bush, one to two feet high, either simple, or sending out one or two ascending branches; outer bark gray, peeling off in shreds; leaves orbicular, broadly ovate, or sometimes obovate, the largest about two inches in diameter, thick, glabrous, light green and shining above, dull and glandular underneath, the margin slightly induplicate, midrib impressed above, prominent beneath; petioles stout, about a fourth of an inch in length;

fully developed cymes large, with densely wooly peduncles an inch in length; calyx very wooly, except the short, triangular lobes, which are almost glabrous, but glandular; petals red, broadly obovate, about a quarter of an inch in length, glandular on the outside, ciliate; stamens numerous, an inch long, dark red; style almost as long, and of the same color as the stamens, not enlarged at the stigmatose apex; ovary deeply immersed in the bottom of the calyx, its disk-like top very glandular and resinous.

The type is No. 2738, collected in the bog at the head of the Wahiawa river, Kauai, at an elevation of 3000 feet. So far as size is concerned, this is near Hillebrand's var. *gamma*, but he says "a low trailing shrub, with stems only 3–6 feet long." This is strictly erect, has larger leaves, and more numerous flowers than his plant. The corolla, stamens, and style are deep red, and the growing ends of the branches are usually tomentose, with traces of pubescence occasionally on the midribs of young leaves. It is probably confined to this bog and the large one on the plateau above Waimea.

Nani(a) macropus (H. & A.) KUNTZE, Rev. Gen. Pl. 242. 1891.

Metrosideros macropus H. & A. Bot. Beechy, 83. 1832.

Typical trees of this species are not uncommon on the slopes of Waiolani, back of Honolulu, but specimens were not collected from them. Hillebrand has the species from Kauai with "leaves contracting at the base." Of my specimens, No. 2762, which was labeled *Metrosideros macropus*, has leaves decidedly contracted at the base, and is not good *macropus*, either according to specimens or the type description. It was collected on the ridge between the Hanapepe and Wahiawa rivers. The specimens are from a small, well proportioned tree. The leaves are elliptical-lanceolate, glabrous, thick and shining, the largest an inch and a half wide by slightly over two inches in length, on bright yellow petioles of almost an inch in length. *Metrosideros macropus* is described as glabrous throughout, yet the peduncles and calyx in these specimens are tomentose. Perhaps the proper course would be to describe it as a new species, for leaving out the pubescence on pedicels and calyx, it is nearer to *N. tremuloides* than to *N. macropus*, where Hillebrand placed it.

Nani(a) glabrifolia n. sp.

A large tree, thirty to forty feet high, with a trunk diameter of two to five feet; main branches stout and spreading, young branches crowded, angled, with short internodes; leaves numerous, broadly ovate, usually cordate at base, on very short petioles, glabrous; the short, stout, peduncles and pedicels as well as the calyx, shortly pubescent, but not wooly; fruit three-fourths free; flowers bright red.

The type is No. 2821, which is abundant at an elevation of 4000 feet, on the plateau above Waimea, Kauai. Specimens with the fruit of the previous season, were collected from a tree which had been blown down during a wind storm. Early in October, when I left this place, the trees were just coming into bloom.

No. 2053, collected en Tantalus, back of Honolulu, may perhaps be referred to *N. glabrifolia.* The specimens were from a small tree. The leaves are on longer petioles, and the flowers are yellowish.

Nani(a) tremuloides n. sp. (*Plate LVI.*)

A small tree, ten to twelve feet high, with slender trunk and smooth, grayish bark, glabrous throughout, even the inflorescence; branches slender, loosely spreading; leaves narrowly lanceolate, pointed at both ends, coriaceous, shining, bright green above, paler beneath, on flat, slightly winged petioles a fourth of an inch in length, not prominently veined, but midrib conspicuous; cyme branches divaricate; peduncles three flowered, slender, of varying length, but always under a half inch; pedicels usually half the length of the peduncles, calyx campanulate, a fourth of an inch in length, green, the lobes equaling the tube, ovate, blunt, margins scarious; petals bright red, almost orbicular, nearly twice the length of the calyx lobes, the margins slightly eroded; stamens bright red, barely an inch in length; styles slightly longer than the stamens, the end curved; fruit half free.

The type is No. 2895. A beautiful and well marked species, with constant characters, at least on the island of Oahu. It seems to be the var. *zeta* of Gray, and is var. *theta* of Hillebrand, who says it is confined to Oahu and Kauai. The natives, who in former times were very good botanists in their way, recognized this form as distinct from the others, and called it "Lehua ahihi." Specimens were collected at the Nuuanu Pali, and at various places on the slopes of Konahuanui, Oahu. It

was also noticed on Kauai, but not in bloom. The lax, and somewhat drooping branches, which, with the leaves, are almost continually in motion, suggested the specific name.

Nani(a) lutea (A. GRAY).

Metrosideros lutea A. GRAY, Bot. U. S. Expl. Exped. **15**:560. 1854.

The type of this was collected on the island of "Hawaii, Sandwich Islands, in the vicinity of Hilo," and is desaribed as follows: "Apparently a tree of considerable size; the branchlets nearly terete, the younger ones only hoary with a fine pubescence. Leaves oval or broadly elliptical, rarely verging to ovate, rounded at both ends, often retuse, sometimes slightly subcordate, coriaceous, 1½ to 2½ inches long, glabrous or early glabrate above, hoary with a minute canescent tomentum underneath, which is very tardily deciduous, closely feather veined, the veins slender, but perspicuous, reticulated, the basal ones produced into an intramarginal false vein. Petiole rather conspicuous, 2½ to 4 lines long. Cymes small, solitary or in pairs at the apex of the branches, not exceeding the leaves, very short peduncled. Bracts caducous. Flowers subsessile or very shortly pedicelled (the pedicels less than a line long, or rarely a line and a half long, often scarcely any), usually in threes at the apex of the partial peduncles. Calyx densely canescent tomentose, as also the inflorescence, about 2½ lines long, campanulate-turbinate, five lobed, the lobes very obtuse. Petals tomentose externally, 'yellow, as well as the stamens,' apparently pale. Filaments and style nearly an inch long."

This seems to be the polymorphous species, rather than *N. polymorpha*, from which it differs in leaf outline, as well as in other particulars. The yellow color cannot be depended upon, for yellow flowers are likely to be found among any of the forms. The form in my collection which most nearly approaches *N. lutea*, is No. 2417, collected on the ridge between the Hanapepe and Wahiawa rivers, Kauai. It is a large tree, and was in full bloom in the third week in June. The leaves are inclined to be acute, and are glabrous. The flowers are dep red.

The next nearest form is No. 2690, collected on the banks of the Wahiawa, just below the second fall. This is a medium sized tree, with narrower, glabrous leaves. The peduncles are longer, but the pedicels are very short. The flowers are yellow, the style a little longer than the stamens.

Another form which may also be placed here rather than with any of the other species, is No. 2484. It grows at lower elevations than the two mentioned above, and is common on the wooded slopes of Hanapepe valley. It came into bloom early in July. The leaves are oblong-ovate, glabrous, as in the other forms, and on short petioles. The pubescence on peduncles and calyx is scanty, and the pedicels are very short, as in No. 2690. The petals have a yellow tinge, and are ciliate, but the stamens are scarlet. The style is a little longer than the stamens, thickened at the apex, and slightly curved. It seems to be the form figured by Mrs. Sinclair, plate 2, of her illustrations of indigenous Hawaiian plants.

Two forms from Oahu do not agree very well with any of the well-marked groups, except that the shape of the leaves would throw them into the *lutea* group. The one form, No. 2219, is a small tree with smooth, light bark. The leaves are lanceolate, glabrous, not conspicuously narrowed at the base, on petioles of half an inch in length. There is a conspicuous intramarginal nerve. The peduncles and calyx are hoary; petals twice the length of the calyx lobes, glandular on the outside, ciliate, dull red, as are the stamens; style as long as the stamens, slightly dilated at the end. Collected on the lower slopes of Konahuanui, at an elevation of 1800 feet.

The other form, No. 2378, has a shorter, almost elliptical leaf, with a tendency to contract at the base, glabrous, distinctly veined, on very short petioles; inflorescence glabrous in old specimens; fruit small, almost free, but included within the calyx. Collected on the slopes of Kohuanui, at 2500 feet elevation. A bush, with stiff, ascending branches and rather crowded leaves, Fruiting specimens only were obtained. Perhaps it is a form of 2219, the difference in growth and leaf form being caused by the increase of elevation and the exposed character of its habitat. There are no large trees at this point, everything being dwarfed and stiff.

PSIDIUM L. Sp. Pl. 470. 1753.

Psidium guajava L. Sp. Pl. 470. 1753.

The Guava is abundant in valleys and in open places in the lower forest of Oahu. The largest and finest fruit was found on the heights of Tantalus and Pauoa. Very few of the sweet fruited bushes are found near Honolulu. On Kauai, on the contrary, bushes which bear sour fruit are rare. It is common

there in Hanapepe valley. Ripe fruit can be found at any season of the year, but is perhaps the most abundant in spring and early summer.

April 5 (2087); original locality, "in Indiis."

ONAGRACEAE.

JUSSIAEA L. Sp. Pl. 388. 1753.

Jussiaea suffruticosa L. Sp. Pl. 388. 1753.

Hillebrand calls this *Jussiaea villosa* LAM. It is very common on both Oahu and Kauai, in low, cultivated ground, and also in wet places in the lower forest.

July to November (2557); original locality, "in Indiis."

UMBELLIFERAE.

CARUM L. Sp. Pl. 263. 1753.

Carum petroselinum (L.) BENTH. & HOOK. Gen. Pl. **1**: 890. 1867.

Apium petroselinum L. Sp. Pl. 264. 1753.

Collected in Hanapepe valley, Kauai, where it grew on the banks of the irrigating ditch. It had escaped from a cultivated piece of ground near by.

July (2689); original locality, "in Sardinia juxta scaturigines."

ARALIACEAE.

CHEIRODENDRON NUTT.; SEEM. Journ. Bot. 5: 236. 1867.

Cheirodendron platyphyllum (H. & A.) SEEM. Journ. Bot. **5**: 236. 1867.

Panax? platyphyllum H. & A. Bot. Beechy, 84. 1832.

Hedera platyphylla A. GRAY, Bot. U. S. Expl. Exped. **15**: 720, *pl. 91.* 1854.

Hillebrand records this species from "the two highest peaks of Oahu, Konahuanui and Kaala." On the plateau above Waimea, Kauai, it is not uncommon, especially far back in the forest, where there is considerable moisture. Here it is a large tree, 25 to 30 feet high, but on the summit of Konahuanui is small and stunted. The leaves are continually in motion, like those of *Populus tremuloides*. The type was collected on Konahuanui, by Lay and Coolie.

May to September (2244).

Cheirodendron trigynum (GAUD.)

Aralia trigyna GAUD. Bot. Voy. Uranie, 474, *pl. 98.* 1830.
Panax? gaudichaudii H. & A. Bot. Beechy, 84. 1832.
Hedera gaudichaudii A. GRAY, Bot. U. S. Expl. Exped. **15**: 719, *pl. 90.* 1854.
Cheirodendron gaudichaudii SEEM. Journ. Bot. **5**: 236. 1867.

A variable species, and perhaps the *Panax? ovatum* of Hooker and Arnott may be distinct. A form, No. 2496, which much resembles it, was collected on the ridge west of the Hanapepe river, Kauai, at an elevation of about 3000 feet. The specimens were taken from a tree about twenty-five feet high. The leaflets are broadly ovate, almost entire. On the plateau above Waimea, specimens were collected which have elongated leaflets, and more conspicuously serrate (2795). The first specimens collected (No. 2313), were obtained back of Honolulu, on the lower slopes of Konahuanui. In these, the leaflets are intermediate in shape between Nos. 2795 and 2496. In all cases the leaflets are in threes.

DIPANAX SEEM. Journ. Bot. 6: 130. 1868.

[**Pterotropia** HILLEBR. Fl. Haw. Is. 149. 1888.]

In his treatment of this genus, Hillebrand discarded Seeman's name of *Dipanax*, and took up the section name *Pterotropia* of Horace Mann, raising it to specific rank. If the three species enumerated below truly belong to a single genus, as held by both Mann and Hillebrand, they must bear the older name of *Dipanax*.

Dipanax dipyrena (MANN)

Heptapleurum (*Pterotropia*) *dipyrenum* MANN, Proc. Am. Acad. **7**: 168. 1867.
Dipanax mannii SEEM. Journ. Bot. **6**: 130. 1868.
Pterotropia dipyrena HILLEBR. Fl. Haw. Is. 150. 1888.

This species was not collected by me. It is said to grow on Lanai, Maui, and Hawaii. The type came from Lanai, and is M. & B. 349.

Dipanax gymnocarpa (HILLEBR.)

Pterotropia gymnocarpa HILLEBR. Fl. Haw. Is. 151. 1888.

Not collected by me. Hillebrand's type was collected by Lydgate, in the valley of Niu, island of Oahu.

Dipanax kavaiensis (MANN)

Heptapleurum (*Pterotropia*) *kavaiense* MANN. Proc. Am. Acad. **7**: 168. 1867.
Agalma kavaiense SEEM. Journ. Bot. **6**: 140. 1868.
Pterotropia kauaiensis HILLEBR. Fl. Haw. Is. 150. 1888.

Collected at the type locality, "mountains above Waimea, Kauai." It was seen only on the brow of the plateau, at an elevation of about 3500 feet. The trees are conspicuous on account of their large leaves. The under sides of the leaves, as well as the inflorescence, are covered with a very thick, fawn-colored, stellate pubescence. It is a large tree, 30 to 40 feet high, with soft wood.

October 16 (2884).

TETRAPLASANDRA A. GRAY, Bot. U. S. Expl. Exped. **15**: 727, *pl. 94*. 1854.

Tetraplasandra waimeae WAWRA, Flora (II) **31**: 158. 1873.

First collected on the edge of the bog at the head of the Wahiawa, Kauai, where it was a small, stunted tree. On Kaholuamano, above Waimea, it is a tree 20 to 40 feet high, with straight trunk and ascending branches. Like all the trees of this family the wood is soft, and easily broken. The full grown fruit is almost an inch in diameter. Wawra's type came from the west side of the Waimea river, "Kauai, um Halemanu 2114."

August to October (2734).

TRIPLASANDRA SEEM. Journ. Bot. **6**: 139. 1868.

Triplasandra waimeae (WAWRA)

Heptapleurum (?) *waimeae* WAWRA, Flora (II) **31**: 159. 1873.
Triplasandra meiandra HILLEBR. Fl. Haw. Is. 152. 1888.

Wawra says that his type came from "Oahu, um Waiolani 1638." Hillebrand says: "Wawra's specific name is wrong; his specimens were collected during a joint excursion with the author upon the western ridge of Nuuanu, Oahu." Acting upon the idea, that because the specimens were not collected at Waimea, the properly published specific name of *Waimeae* must be abandoned, he invented the name of *meiandra*, and reduced Wawra's type to a variety, calling it var. *a*. This species was not collected by me.

VACCINIACEAE.

VACCINIUM L. Sp. Pl. 349. 1753.

Vaccinium penduliflorum GAUD. Bot. Voy. Uranie, 454, *pl. 68.* 1830.

Nuttall considered these Hawaiian plants distinct from *Vaccinium*, and proposed a new generic name for them, calling them *Metagonia.* It is very probable that he was correct, for in general appearance they do not much resemble *Vaccinium.* The red fruit has a different taste, more like that of a cranberry. This species is not uncommon on the ridge back of Honolulu, and also occurs on the mountain of Kauai.

May to September (2393).

EPICRADACEAE.

CYATHODES LABILL. Nov. Holl. Pl. **1**: 57, *pl. 81.* 1804.

Cyathodes imbricata STSCHEGLEW, Mosc. Bull. **32**: 10. 1859.

Only the variety *struthioloides* is recorded from Kauai, in "swamps of Lehua makanui and summit of Waialeale." It is described as "stems slender, trailing on the ground, densely covered with prominent leaf scars, and with few assurgent branches." In the bog at the head of the Wahiawa, plants are plentiful, which are to be referred to the species rather than to the variety. The branches are either trailing or erect. The species has previously been found only on "higher regions of Mauna Loa, Mauna Kea, and Haleakela."

August 21 (2739).

Cyathodes tameiameiae CHAM. Linnaea, **1**: 539. 1826.

Named after Kamehameha, the famous Hawaiian king, who united all of the islands of the group into one kingdom. The letters T and K, as well as R and L, are interchangeable in the Hawaiian language. Rather common on the ridges of Oahu and Kauai, and the bushes very showy when covered with the bright red berries, It is a much branched bush, three to six feet high.

April to September (2181a, 2454); original locality, "inclivis aridioribus ad radices montium circa Hana-ruru insulae O-Wahu."

MYRSINACEAE.

MYRSINE L. Sp. Pl 196. 1753.

Myrsine gaudichaudii A. DC. Ann. Sp. Nat. (II) **16**: 85. 1841.

To this species are referred three numbers collected on the ridge west of the Hanapepe river, Kauai. In the Prodromus, the leaves are described as "oblongo-obovatis obtusis basi in petiolum angustatis coriaceis * * * Folia * * * petiolo 3 lin. longa, valde coriacea." The leaves in all of my specimens answer essentially to this description, and are much thinner than in the specimens referred to *M. lessertiana.* This is especially true of No. 2530, and in 2531 they are inclined to be acute, as noted by Hillebrand.

July to August (2530, 2531, 2682).

Myrsine kauaiensis Hillebr. Fl. Haw. Is. 280. 1888.

This handsome and well-marked species was collected at an elevation of 3000 feet, on the ridge west of the Hanapepe river, Kauai. The leaves are thin, and somewhat pubescent, even when old. It is a small tree, with slender, spreading branches. Hillebrand's type was collected by Knudsen, on the west side of the Waimea river.

August 6 (2679).

Myrsine lanceolata (Wawra)

Myrsine sandwicensis var. *lanceolata* Wawra, Flora (II) **32**: 526. 1874.

Hillebrand makes no mention of this plant, which accounts for the sending out of specimens by me under the name *Myrsine tenuifolia*, n. sp. Wawra describes it as "arbuscula trunco contorto; ramulis gracilibus pendulis parce foliosis; folia lineari lanceolata, tenera." He collected it in "feuchte Wälder von Makanoi, 2135," which means the large bog on the plateau above Waimea. My specimens were collected in the bog at the head of the Wahiawa, and differ only in having ascending instead of drooping branches. However, small trees were seen high up on the ridge west of the Hanapepe river, which did have spreading and drooping branches. That it is a good species, quite distinct from *M. sandwicensis,* is evident. The narrowly lanceolate, acuminate leaves are different, and the fruit is mostly borne in the axils of the leaves, and not below on the naked stems, as is the case in the other species.

August 12 (2700).

Myrsine lessertiana A. DC. Ann. Sc. Nat. (II) **16**: 85. 1841.

This species is described as having lanceolate leaves, acute at each end. Specimens with such leaves were collected on the lower slopes of Konahuanui, back of Honolulu, at an elevation of about 1800 feet. The leaves are also stiff and coriaceous.

May 13 (2304).

Myrsine sandwicensis A. DC. Ann. Sc. Nat. (II) **16**: 85. 1841.

Collected on the slopes of Konahuanui, Oahu, at 2500 feet elevation. This species appears to grow only on the edges of steep slopes where vegetation is more or less stunted. It was seen in similar situations on the ridge west of the Hanapepe river, Kauai. The leaves are small, often not over an inch in length, obovate or spatulate, thick and coriaceous. It is a freely branching shrub. No. 2379.

With the last number was collected a form with leaves of the same shape and texture, but considerably larger. The flower clusters were also much thicker. This is probably Wawra's variety *grandifolia* "aus Hillebrand's Herbar. 2381," but Hillebrand makes no mention of it. No. 2380.

PRIMULACEAE.

ANAGALLIS L. Sp. Pl. 148. 1753.

Anagallis arvensis L. Sp. Pl. 148. 1753.

On the grassy slopes of the Nuuanu Pali, Oahu, this little plant has obtained a foothold, and is well established. There is no record of its occurrence in the Islands, nor was it seen at any other place.

May 24 (2366); original locality, "in Europae arvis."

LYSIMACHIOPSIS gen. nov.

Shrubs, either loosely branched and spreading, or simple and erect; branches and stems often roughened with the scars of fallen leaves, the growing ends covered with reddish tomentum; leaves of medium size, alternate, sometimes appearing as if whorled; flowers in the upper axils, on pedicels nearly as long, or sometimes longer than the leaves, purple or red; calyx parted to the base or almost so, into five to nine lobes; corolla urceolate, the lobes imbricate, five to nine in number; stamens united at the base by a granular membrane, which is attached to the base of the corolla, as many as the lobes of the corolla,

and opposite them, filaments comparatively long, slightly dilated at the base, anthers oblong, one-third the length of the filaments, slightly pointed; capsule ovoid, woody or crustaceous, breaking from the style at the top, into as many valves as there are calyx and corolla lobes.

A genus hitherto confused with *Lysimachia*, from which it differs primarily in being composed of shrubs instead of herbs, and by having red or purple, urceolate flowers.

Lysimachiopsis daphnoides (A. GRAY)

Lysimachia Hillebrandii var. *daphnoides* A. GRAY, Proc. Am. Acad. **5**: 329. 1862.

Lysimachia daphnoides HILLEBR. Fl. Haw. Is. 285. 1888.

An erect, simple stemmed shrub, one to three feet high. Occasionally there is a tendency to branch, but this seems due to some injury which the plant has received. On some plants the pedicels are very long and recurved. In flowers which have not matured, the calyx is reflexed, as is shown in Plate LVII. The obovate-oblong, crowded leaves are sessile. Collected in fruit only, at an elevation of 3000 feet, in the bog at the head of the Wahiawa river, Kauai, where it is plentiful. Gray's original came from the large bog on the plateau above Waimea.

August 21 (2736).

Lysimachiopsis hillebrandii (HOOK. f.)

Lysimachia hillebrandii Hook. f.; A. GRAY, Proc. Am. Acad. **5**: 328. 1862.

Specimens were collected on the ridges west of the Hanapepe river, Kauai, at elevations of 3000 feet and more. The plant is rather common, and answers well to the description of this species, as given by Hillebrand, with the exception of "stamens ½ the length of the corolla or little more." They are slightly exserted, and therefore longer than the corolla. It is a bush, with rambling branches, which are two or three feet long in some cases. The calyx is almost half the length of the corolla, the lobes lanceolate, acuminate, scarious margined. The corolla is about three-fourths of an inch in length, purple, the ovate lobes acutish, with broad greenish or whitish, eroded margins. The filaments are a quarter of an inch in length, and therefore not "short," as given by Hillebrand, in his generic description of *Lysimachia*. No. 2614, from which the generic description is mostly drawn, and represented by Plate LVIII.

Lysimachiopsis lydgatei (HILLEBR.)

Lysimachia lydgatei HILLEBR. Fl. Haw. Is. 284. 1888.

The type of this species came from Maui, "on slopes and in gulches back of Lahaina," presumably collected by Lydgate.

Lysimachiopsis ovata n. n.

Lysimachia rotundifolia HILLEBR. Fl. Haw. Is. 284. 1888, not Schmidt.

Record from Nuuanu valley, Oahu. Hillebrand's specific name is not tenable on account of the earlier *L. rotundifolia* of Schmidt.

Lysimachiopsis remyi (HILLEBR.)

Lysimachia remyi HILLEBR. Fl. Haw. Is. 284. 1888.

This was originally called *Lysimachia hillebrandii* var. *angustifolia*, by Asa Gray, but as the name *angustifolia* had already been used several times in that genus, Hillebrand very properly changed it.

OLEACEAE.

OLEA L. Sp. Pl. 8. 1753.

Olea sandwicensis A. GRAY, Proc. Am. Acad. 5: 331. 1862.

Common in the lower forest of Kauai. Usually a tree of medium size, with large, elliptical-lanceolate leaves, and numerous axillary racemes of cream-colored flowers. Collected near the Wahiawa river, Kauai, but it is also found on the ridge west of the Hanapepe river. It was not seen above an elevation of 2500 feet. A form with obtuse instead of pointed fruit, is noted from Kauai by Hillebrand.

June to August (2415); original locality, "Oahu, Sandwich Islands."

LOGANIACEAE.

LABORDEA GAUD. Bot. Voy. Uranie, 449, *pl. 60*. 1830.

Labordea pallida MANN, Proc. Am. Acad. 7: 196. 1867.?

The type of this species is M. & B. 611, and according to Hillebrand, was collected near Kealia, Kauai, although the locality is not mentioned by Mann. I have specimens from Kaholuamano, above Waimea, Kauai, which may belong to this species. They were taken from a small tree, about fifteen feet high, with

slender trunk, and spreading top. The leaves, as described by Mann, are ovate-oblong and glabrous, but the petioles are four or five lines long, which is somewhat longer than his description calls for. . No flowers were seen, but the woody capsule is almost an inch in length, rather slender and pointed.

September 25 (2868).

Labordea tinifolia A. GRAY, Proc. Am. Acad. **4**:322. 1860.

Specimens obtained from a medium-sized tree on the ridge west of the Hanapepe river, Kauai, match well with a specimen of this species in the herbarium of Columbia University. Hillebrand records it from Oahu and Maui only. He evidently has this genus badly confused, for it is hardly possible to determine any of the species by using his key and descriptions.

July (2579).

GENTIANACEAE.

ERYTHRAEA NECK. Elem. 2:10. 1790.

Erythraea sabaeoides (GRISEB.) A. GRAY, Proc. Am. Acad. **6**:41. 1863.

Schenkia sabaeoides GRISEB. Bonplandia, **1**:226. 1853.

Collected in low ground near Diamond Head. It was also seen in Kalihi valley. A small, smooth plant with lavender colored flowers.

March 20 (2026).

APOCYNACEAE.

GYNOPOGON FORST. Char. Gen. 35, *pl. 18.* 1776.

[**Alyxia** BANKS; R. BR. Prodr. Fl. Nov. Holl. 469. 1810]

Gynopogon olivaeformis (GAUD.)

Alyxia olivaeformis GAUD. Bot. Voy. Uranie, 451. 1830.

The "Maile" is a favorite plant with the Hawaiian for the making of wreaths and other decorations. It is usually vine like in habit, often forming quite a tangle on bushes and small trees. The dark green, thick and glossy leaves are variable in shape, but usually ovate or lanceolate. The fruit is black, somewhat spindle-shaped. Collected on both Oahu and Kauai, ranging from 2,500 to 4,000 feet elevation.

May to October (2344).

RAUWOLFIA L. Sp. Pl. 208. 1753.

Rauwolfia sandwicensis A. DC. Prodr. 8:339. 1844.

A small tree, with smooth, yellowish bark, and stiff, spreading branches. It is rather common in the lower woods on the lee side of Kauai.

July 17 (2582).

ASCLEPIADACEAE.

ASCLEPIAS L. Sp. Pl. 214. 1753.

Asclepias curassavica L. Sp. Pl. 215. 1753.

An introduced species, which is well established on Oahu and Kauai. On the latter island it has found its way well up into the lower forest, in open, grassy places.

March to September (1950); original locality, "in Curassao."

CONVOLVULACEAE.

CRESSA L. Sp. Pl. 223. 1753.

Cressa truxillensis H. B. K. Nov. Gen. 3:119. 1818.

Collected at Pearl river, Oahu, "east of the inlet," as mentioned by Hillebrand, who, however, calls it *Cressa cretica*. It is identical with specimens of *C. truxillensis*, collected in Peru by the botanists of the U. S. Exploring Expedition. It is plentiful along Pearl river, and was also collected on Molokai by Remy. The anthers are violet.

June 10 (2410); original locality, "in arenosis salsis Oceani Pacifici, prope Truxillo Peruvianorum."

JACQUEMONTIA Choisy, Mem. Soc. Phys. Genev. 6:476. 1833.

Jacquemontia sandwicensis A. Gray, Proc. Am. Acad. 5:336. 1862.

When growing in exposed situations, the plants of this species are liable to be very small, erect and bushy, but under more favorable conditions, they have stems two to three feet long, which are prostrate and creeping. The pale blue corolla is almost an inch in diameter. Collected on an ancient lava flow beyond Diamond Head, Oahu.

April 12 (2095).

IPOMOEA L. Sp. Pl. 160. 1753.

Ipomoea congesta R. Br. Prodr. Fl. Nov. Holl. 485. 1810.

Ipomoea insularis CHOISY; STEUD. Nomencl. Bot. Ed. 2, 817. 1841.

Common on slopes and about the lower edge of the forest on Oahu. The flowers are bright blue when fresh, but turn pink when dried. The rounded, cordate leaves are more or less pubescent on both sides.

May 16 (2324).

Ipomoea pes-caprae (L.) Sw.

Convolvulus pes-caprae L. Sp. Pl. 159. 1753.

Common along the beach in sand, on all of the islands of the group. Collected at Waikiki, near Honolulu.

April to June (2097); original locality, "in India."

Ipomoea palmata FORSK. Fl. Aegypt. Arab. 43. 1775.

Hillebrand calls this *Ipomoea tuberculata* var. *trichosperma*, but does not state whether it is his own creation, or if he has reduced *Ipomoea trichosperma* BLUME, to a variety. Horace Mann, who was a very acute botanist, determined it as *I. palmata.* Common on the hot, dry, lower slopes, trailing over lava rocks and bushes. It is somewhat variable in leaf form. The flowers are pale red, or pinkish.

March 29 (2045).

HYDROPHYLLACEAE.

CONANTHUS S. Wats. Bot. King Surv. 256. 1871.

[**Nama** L. 1759, not L. 1753.]
[**Marilaunidium** KUNTZE, Rev. Gen. Pl. 434. 1891.]

Conanthus sandwicensis (A. GRAY)

Nama sandwicensis A. GRAY, Proc. Am. Acad. **5**: 338. 1862.

A few plants were collected at Waikiki, Oahu, and later several more at Mana, Kauai, in low ground near the sea. A small plant, in appearance much like the various species which have until recently been called *Nama*, and which are found in the southwestern part of the United States. According to Mr. Coville, Cont. U. S. Nat. Herb. **4**: 161, *Conanthus aretioides* can not be separated generically from the plants which we have wrongly been calling *Nama*, and therefore *Conanthus* is the next available name, a fact which Kuntze was not aware of when he proposed *Marilaunidium*.

March to August (1956).

BORAGINACEAE.

BOTHRIOSPERMUM Bunge, Enum. Pl. Chin. Bor. 47. 1832.

Bothriospermum tenellum F. & M. Ind. Sem. Hort. Petr. 24. 1835.

Hillebrand notes this species from "along cultivated fields in Pauoa, Oahu. A native of China and India; a recent arrival." It does not seem to have spread outside of Pauoa, where it is now rather common.

March 26 (2008).

HELIOTROPIUM L. Sp. Pl. 130. 1753.

Heliotropium curassavicum L. Sp. Pl. 130. 1753.

This widely diffused species is common in low places along the beach, presumably on all of the islands of the group. It is found on Oahu and Kauai, at least.

May (2383); original locality, "in Americae calidioris maritimis."

VERBENACEAE.

CLERODENDRON L. Sp. Pl. 637. 1753.

Clerodendron fragrans Vent. Jard. Malm. *pl. 70.* 1804.

A form with double flowers has escaped along the roadside in Nuuanu valley, Oahu. Hillebrand mentions it as var. *pleniflora*. The large, broadly ovate leaves are pubescent on both sides. The flowers are white, tinged with pink or purple.

March 29 (2032).

LANTANA L. Sp. Pl. 626. 1753.

Lantana camara L. Sp. Pl. 627. 1753.

This species has become the most noxious plant in the Islands. Introduced in 1858, it is now abundant, and has ruined hundreds of acres of valuable pasture land. It forms impenetrable thickets on the slopes and in gulches of the lowlands, and has even invaded the lower forests. Here it grows in thick clumps, the stems often becoming weak and vine-like, and intertwining in a very intricate manner. The flowers vary in color, some being almost white, others purplish, and some are orange.

April 5 (2088); original locality, "in America calidiore,"

STACHYTARPHETA Vahl. Enum. 1:205. 1805.

Stachytarpheta dichotoma (R. & P.) Vahl. Enum. **1**:207. 1805.

Verbena dichotoma R. & P. Fl. Per. **1**;23. 1798.

Two forms of this species were collected. One, No. 2091, which is most common in the immediate vicinity of Honolulu, is woody only at the base, the stout, herbaceous branches somewhat weak, about two feet long, almost glabrous, and somewhat glaucous. The other form, No. 1098, is usually found at higher elevations, and even extends to the lower edge of the forest. It is an erect, branching shrub, only the young branches herbaceous, On Kauai, bushes five feet high, with stems an inch in diameter were seen in Hanapepe valley. The leaves on this form are brighter green, somewhat smaller, and more sharply serrate. It is possible that the two are distinct species, but No. 2091 would seem to be a young state of the latter. Hillebrand describes it as an "erect herb," and records it from the island of Hawaii, "districts of Hilo and Kona," only.

VERBENA L. Sp. Pl. 18. 1753.

Verbena bonariensis L. Sp. Pl. 20. 1753.

A widely diffused tropical weed, introduced many years ago, and now found on all of the islands of the group. It can be found anywhere from the low, cultivated ground near the coast, to pasture land high up in the mountains; everywhere, in fact, except in the deep forest where introduced plants rarely find a lodging.

March to September (2088); original locality, "in agro Bonariensi."

VITEX L. Sp. Pl. 638. 1753.

Vitex trifolia L. Sp. Pl. 638. 1753.

The hoary under sides of the leaves, and the blue flowers, make this a showy species. It is plentiful on the "barking sands" of Mana, Kauai. The main stems, which are decumbent and quite long, spread out over the sand, sending up branches at intervals of a half foot or less. Horace Mann, Proc. Am. Acad. 7:194, calls this "*Virtex trifolia*, Linn., var.? *unifoliolata*," and Hillebrand has it "var. *unifoliata*," with no indication that he is not the author of the varietal name. However, it is a *nomen nudum*, as Mann does not describe it, and if it were distinct, would probably have to be called *Vitex ovata* Thunb. My specimens show leaves varying from

three-foliolate to entire, some of them being two-lobed. The original spelling in the Species Plantarum is *Vitex "trifoliis,"* undoubtedly a typographical error.

August 20 (2731); original locality, "in Indiis."

LABIATAE.

PHYLLOSTEGIA Benth. DC. Prodr. 12: 553. 1848.

All authorities cite this genus as published in Lindley's Botanical Register 15; *pl. 1292.* 1830. The plant under that figure is called *Lepechinia spicata* Willd., and as no reference is anywhere made to this name, it evidently means that the figure is not really that of *Lepichina spicata*, but represents an undescribed genus, and is the type of *Phyllostegia*, which, so far as I can ascertain, was first characterized in the Prodromus, as cited above.

Phyllostegia grandiflora (Gaud.) Benth. DC. Prodr. **12**: 553. 1848.

Prasium grandiflorum Gaud. Bot. Voy. Uranie, 453, *pl. 65, f. 2.* 1830.

Stems often six or eight feet long, woody below, the greater part herbaceous, and leaning for support over other bushes, thus giving them a vine like habit. In the older plants, the leaves become thick and shining above. In some respects these more mature forms agree with *P. glabra*, as described by Hillebrand, but the two forms are often found in the same clump. The flowers are large, white, pubescent, with long, exserted tube.

May to November (2299).

Phyllostegia waimeae Wawra, Flora (II) **30**: 531. 1872.

A handsome species, with rather small, pink, sweet scented flowers. The plant is pubescent throughout, four to five feet high, the herbaceous branches somewhat climbing. Collected on Kaholuamano, above Waimea, Kauai. It grew along the banks of a forest stream, in a thick growth of ferns. Wawra's type came from the opposite side of the Waimea river, "Halemann (Bezirk Waimea)."

September 25 (2860).

Phyllostegia

Growing with *P. waimeae*, but a very different plant. The leaves are much larger, thicker, darker green, and have a coarser pubescence. The racemes are much longer, and more branched, the involucral bracts are shorter, the pedicels much longer and more slender, and the calyx lobes broader at the base. The flowers are about the same size, but white. It is probably an undescribed species, but Hillebrand's treatment of this genus is not satisfactory, hence making it unsafe to describe a new species without a more extensive suite of specimens.

October 12 (2875).

PLECTRANTHUS L'Her. Stirp. Nov. 84, *pl. 42.* 1785.

Plectranthus australis R. Br. Prodr. Fl. Nov. Holl. 506. 1810.

Plectranthus parviflorus Willd. Hort. Berol. *pl. 65.* 1816 not R. Br.

Common on rocks in Hanapepe valley, Kauai. Also noticed growing on the ground, in an open space in the woods above Waimea. It is a fleshy plant, and hard to dry. The pale blue flowers are numerous, but small, in a long terminal raceme.

June 29 (2467).

SALVIA L. Sp. Pl. 23. 1753.

Salvia occidentalis Sw. Nov Gen. et. Sp. 14. 1788.

A common weed on the slopes of Hanapepe valley, Kauai. Also found about Honolulu. The blue flowers are very small.

May 9 (2291).

Stenogyne rotundifolia A. Gray, Proc. Am. Acad. 5:347. 1862.

Hillebrand has taken an unwarranted liberty with this species. In his Flora, he re-names the type as var. *montana*, and chooses another plant for *his* type of the species. The plant which he calls *S. rotundifolia*, is *S. macrantha*, M. & B. 402, and *S. haliakalae* Wawra, according to his citation of synonyms, on page 360.

STACHYS L. Sp. Pl. 580. 1753.

Stachys arvensis L. Sp. Pl. Ed. 2, 814. 1763.

Very common about Honolulu, along the street, and in cultivated ground,

March 29 (2034); original locality, "in Europae arvis."

SOLANACEAE.

CAPSICUM L. Sp. Pl. 188. 1753.

Capsicum frutescens L. Sp. Pl. 189. 1753.

Cultivated at Honolulu, and occasionally found as an escape. Several bushes were found on the slopes of Makiki.

March 29 (2086); original locality, "in Indiis."

LYCIUM L. Sp. Pl. 191. 1753.

Lycium sandwicense A. Gray, Proc. Am. Acad. 6:44. 1863.

Plentiful on an old lava flow beyond Diamond Head, Oahu. It flourishes at a distance of several hundred feet from the sea, but even at that distance the salt spray is brought to it by the wind. It is also found at other places in low ground along the coast.

April 8 (2093); from the original locality, "Sandwich Islands, on Diamond Hill, Oahu, near Honolulu."

LYCOPERSICUM Hill. Veg. Syst. 9:32. 1765.

Lycopersicum esculentum Mill. Gard. Dict. Ed. 8, No. 2. 1768.

The tomato is found in the wild state on both Oahu and Kauai. It is plentiful about Punchbowl, and was noticed high up in pasture land above Waimea, Kauai. The fruit is small, usually not more than an inch in diameter, and never takes the irregular forms which it does in cultivation.

March 25 (1998).

NICOTIANA L. Sp. Pl. 180. 1753.

Nicotiana glauca R. Grah. Edinb. N. Phil. Journ. 175. 1828.

A small, soft-wooded tree, which is not uncommon about Honolulu, especially along the water front. The flowers are numerous, pale yellow.

March 27 (2016).

NOTHOCESTRUM A. GRAY, Proc. Am. Acad. 6:48. 1863.

Nothocestrum latifolium A. GRAY, Proc. Am. Acad. 6:48. 1863.

The original of this was a "shrub about 12 feet high," and came from "Oahu, on the ridge of the Kaala mountains." It is described as follows by Gray: "Leaves membranaceous, about 2 inches long. * * * Calyx 3 lines long. Corolla white? its tube half an inch long, the lobes not half the length of the tube, their margins strongly induplicate, and the sinuses plaited. Anthers two lines long." Hillebrand records it from Waimea, Kauai, with "leaves emarginate at the base, coriaceous, with ochraceous tomentum." My specimens are in young fruit, and do not agree with this species in some particulars. It may possibly be an undescribed species. The mature leaves are about four inches in length, and more inclined to be oblong than ovate, densely pubescent underneath. Collected on the edge of the plateau above Waimea, Kauai, at an elevation of 3500 feet. A tree, twenty feet high, with gray bark, and zigzag branches.

October 16 (2886).

PHYSALIS L. Sp. Pl. 182 1753.

Physalis peruviana L. Sp. Pl. Ed. 2, 1671. 1763.

Abundant along the lower edges of the forest on Oahu and Kauai, and according to Hillebrand, also on Maui and Hawaii. The berry is gathered and made into jelly and jam. Called "Poha," by the natives.

April 2 (2060); original locality, "Limae."

SOLANUM L. Sp. Pl. 184. 1753.

Solanum nigrum L. Sp. Pl. 186. 1753.

Common in Hanapepe valley, Kauai, and on the edge of the woods above Waimea. It also occurs on Oahu. The small black berries are eaten by the natives.

July to October (2509, 2867).

Solanum sandwicense H. & A. Bot. Beechy, 92. 1832

Collected at an elevation of 3000 feet, on the ridge west of the Hanapepe river, Kauai. It differs somewhat from Hillebrand's description of "Corolla puberulous outside, bluish white, 5–6″ in diameter, 5 fid to the middle, plaited. Anthers

almost sessile, scarcely ½ the length of the corolla." The corolla in my specimens is cream colored, with purple centre, and purple stripes, extending about half way up the petals, the lobes of which are parted almost to the base. The stamens are two-thirds the length of the corolla, and have distinct, smooth filaments.

July 29 (2638); original locality, Oahu.

Solanum sodomeum L. Sp. Pl. 187. 1753.

This African species, although not recorded by Hillebrand, is well established about Honolulu. The flowers are pale purple, and the fruit yellow. The stem and leaves are covered with stout, yellow spines.

June 10 (2409).

SCROPHULARIACEAE.

MONNIERA P. BROWNE, Civ. & Nat. Hist. Jam. 269, *pl. 28, f. 3.* 1755.

[**Herpestis** GAERTN. Fr. & Sem. **3**: 186, *pl. 214, f. 6.* 1805.]

Monniera monniera (L.) BRITTON, Mem. Torr. Bot. Club. **5**: 292. 1894.

Gratiola monniera L. Centl. Pl. **2**: 1756.
Herpestis monniera H. B. K. Nov. Gen. **2**: 366. 1817.

Common in wet places near the coast, as at Waikiki, and Pearl City, Oahu.

June 10 (2408).

GESNERIACEAE.

CYRTANDRA FORST. Char. Gen. **5**: *pl. 3.* 1776.

Cyrtandra cordifolia GAUD. Bot. Voy. Uranie, 446, *pl. 56.* 1830.

According to Hillebrand, this species is "common on the main range" of Oahu. It was seen at one place on Tantalus, back of Honolulu. The large, broadly ovate, oblique leaves, as well as the inflorescence and young branches, are covered with tawny hair. It is a much more fleshy plant than some of the other species.

April 11 (2112).

Cyrtandra degenerans (WAWRA)

Cyrtandra paludosa, var. *degenerans* WAWRA, Flora (II) **30**: 558. 1872.

Cyrtandra longifolia, var. *degenerans* C. B. CLARKE, DC. Monog. Phan. **5**: 277. 1883.

Cyrtandra latebrosa HILLEBR. Fl. Haw. Is. 337. 1888.

It appears that Hillebrand had also given this the manuscript name of *C. paradoxa.* He considered it sufficiently distinct for specific rank, and this is made more probable by the fact that it grows on Oahu, while *C. longifolia* has been found only on Kauai.

Cyrtandra gayana n. sp. (*Plate LIX.*)

A small tree, ten feet high; trunk usually four inches in diameter, bark gray; top rounded; secondary branches slender, rough, somewhat quadrangular, studded with the scars of fallen leaves; leaves opposite, confined to the ends of the branches, lanceolate, tapering at both ends, two to three inches long, one-half to three-fourths of an inch wide, entire, bright green above, with impressed midrib and veins, brown beneath, and sparingly pubescent on the prominent, dark midrib and veins; petioles a half inch in length; flowers solitary in the axils of the leaves; peduncles an inch or less in length, subtended by small, linear, deciduous bracts; calyx a half inch in length, somewhat pubescent, thin, almost cylindrical, peaked in the bud, unequally five-toothed, deciduous from the fruit; corolla white, little exserted, slender, moderately curved, not quite an inch in length, not strongly bilabiate, the lobes short; stamens two, anthers broad and connected at their tips, as in the genus; style short, two-lobed; fruit white, ovate oblong, five lines in length, tipped with the persistent style.

The type is No. 2495, which was collected on the ridge west of the Hanapepe river, Kauai, at an elevation of 3000 feet. It also occurs on the plateau above Waimea, at 4000 feet elevation. Named in honor of Mr. Francis Gay, of Makaweli, Kauai, to whom I am much indebted for hospitalities shown to me while on the island of Kauai. It belongs to the group of which *C. paludosa* is the type. From that species it differs in its arborescent habit, narrower, entire leaves, which are brown underneath, instead of pale, and by its smaller flowers and fruit. There is a possibility that it may be *Cyrtandra paludosa*, var. *arborescens* WAWRA, Flora (II) **30**: 558, which is described as "frutex pyramidalis densissimus, foliis ellipticis in petiolum longe attenuatis integris. Folia subcoriacea glabra,

bacca vix ½ pollicem longa; nervis secundariis confertis." Wawra's specimen's were collected on Kauai, but no locality is mentioned. The name *arborecens*, however, is antedated by *C. arborecens* BLUME, which would make my name valid, even if my plants are the same as Wawra's.

Cyrtandra grandiflora GAUD. Bot. Voy. Uranie, 447 *pl. 55.* 1830.

A few specimens were collected at the head of Kalihi valley, Oahu. In all cases noticed, the large white flowers were borne on the branches below the leaves. The bracts in this species are large and foliaceous. The leaves are large, thin, ovate-oblong, on long petioles. Found only on Oahu.

May 20 (2336).

Cyrtandra kalichii WAWRA, Flora (II) **30**: 564. 1872.

Cyrtandra tristis HILLEBR. in C. B. Clarke, DC. Monog. Phan. **5**: 227. 1883.

This odd-looking species was collected at the type locality, "Oahu, felsschluchten des Kalichithals." It is a shrub, several feet high, simple, or with a few ascending branches. The leaves are often fifteen inches in length, obovate or oblong, with broadly winged petioles which are clasping or united at the base. The whole plant is more or less pubescent with tawny hairs. Under this species Hillebrand, Fl. Haw. Is. 334, cites "*C. tristis*, Hbd. in herb." C. B. Clarke, as cited above, has described it for Hillebrand, quoting "Hillebrand ms."

May 20 (2337).

Cyrtanda kauaiensis WAWRA, Flora (II) **30**: 566. 1872.

Found in a gulch above Waimea, Kauai, between the forks of the Waimea river, at an elevation of about 2000 feet. It is a shrub, with few and slender branches, foliose only at the ends, and somewhat quadrangular. It was rare, as only one or two bushes were seen.

September 30 (2829); original locality, "Kauai, Wälder von Halemanu."

Cyrtandra kealiae WAWRA, Flora (II) **30**: 565. 1872.

Not uncommon on the ridges along the Wahiawa river, Kauai, and also found on the ridges west of the Hanapepe river, at elevations of 2500 to 3000 feet. A freely branching bush, about five feet high, the young branches, inflorescence, and under sides of the leaves tomentose with bright yellow hairs; fruit enclosed in the densely hairy calyx.

July to August (2543); original locality, "Kauai, um Kealia."

Cyrtandra lessoniana GAUD. Bot. Voy. Uranie, 447, *pl. 54.* 1830.

This appears to be a variable species, and forms between it and *C. pickeringii* are found. My No. 2300 a has characters which point toward the latter species. The leaves are broader and thicker than in the typical plant, but it has the calyx lobes parted to the base, as is ordinary. No. 2896 appears to be typical. It was collected on Konahuanui, back of Honolulu, at elevations of 1500 to 2000 feet.

Cyrtandra lessoniana pachyphylla HILLEBR. Fl. Haw. Is. 331. 1888.

A form which appears to belong here, was collected on the slopes of Konahuani, at an elevation of about 2500 feet. The leaves are thick and leathery with prominent veins, and are densely tomentose on the lower side. The peduncles are one flowered.

May 23 (2351).

Cyrtandra longifolia (WAWRA) HILLEBR. in C. B. Clarke, DC. Monog. Phan. **5**:276. 1883.

Cyrtandra paludosa var. *longifolia* WAWRA, Flora (II) **30**: 558. 1872.

The following is Wawra's description: "Frutex biorgyalis foliis anguste lanceolatis brevissime petiolatis, subtus ad nervos brunneo-hirsutis integris. Calyce extus hirsuto. Pauciramosus. Folia ad caulis apicem congesta ½-1 ped. longa, 1½ poll. lata, subtus spongioso furfuracea (novella brunneo tomentosa) subsessilia vel in petiolum semipollicarem hirsutum repentine—rarius sensim contracta. Calyx tener, cylindraceus subaequaliter 5 lobus, lobis lanceolatis acutis 3 lin. longis. Corollae tubus gracillis pollicaris. Bacca anguste oblonga, pollicaris. Kauai, Walder von Hanalei; 1991a." To this I must refer my No. 2624, which includes two forms. The leaves are the same shape in both forms, either lanceolate or spatulate lanceolate, and always contracted at the base, on petioles of almost a half inch in length. The one form is almost smooth, with leaves inclined to be pale underneath. The flowers are on slender pedicels of nearly two inches in length, and are provided with two folicaeous, ovate bracts. The other form has the under sides of the leaves covered with brown scales, or with brown hairs on the petioles, midribs, pedicels and calyx. There is no evidence of bracts on the pedicels, but they show an articulation near the base. The two forms are similar in habit and appearance, and grow together in wet woods along

the Wahiawa river, Kauai. It is a branching bush, five to six feet high. The largest leaves are barely six inches in length. I have distributed it as *Cyrtandra Wahiawae* n. sp., but until there is an opportunity for comparison with Wawra's specimens, which are preserved at Vienna. I cannot be shure that they are distinct from *C. longifolia.* Wawra states very plainly that the type of his var. *longifolia* is No. 1991a, yet Mr. Clarke cites both 1991a and 1991b as types. The latter number is the type of var. *arborescens*, according to Wawra, who ought to know his own specimens, while Mr. Clarke says 1991c is the type of that plant. Hillebrand, although his Flora was published five years later than Mr. Clarke's paper, makes no mention of *C. longifolia* or *C. scabrella* Clarke, the type of the latter being "Hillebrand, n. 324 in h. Kew." Presumably his manuscript was prepared previous to 1883, and not afterwards revised.

Cyrtandra oenobarba MANN, Proc. Am. Acad. 7: 189. 1867.

A rare species, collected on rocks at the base of a small waterfall in Hanapepe valley, Kauai. The short, herbaceous stems are hidden in the crevices of the rocks, and send out numerous fibrous roots, which give the plant the appearance of being stemless. In my specimens, the lower leaves are on petioles longer than the blade. A few plants were collected at Hanapepe falls, growing on a rock wall, where they were continually kept moist by the dripping water.

July 5 (2490); original locality, "Wahiawa falls, and in Waioli valley, Kauai."

Cyrtandra oenobarba herbacea (WAWRA)

Cyrtandra paludosa. var. *herbacea* WAWRA, Flora (II) **30**: 559. 1872.

Wawra's specimens came from Hanapepe falls, Kauai, and if they are the same as specimens which I collected there, then they are more nearly related to *C. oenobarba* than to *C. paludosa.* They were distributed as *C. oenobarba.* As described by Wawra, it is "herbacea procumbens, foliis succulentis grosse serratis, pedunculis brevissimis plurifloris, pedicellis brevibis." The leaves are about eight inches in length, including petioles of three to four inches. They are three inches broad, pointed at both ends, coarsely serrate, the petioles, midrib and veins covered with coarse, brown hair.

July (2490, in part).

Cyrtandra paludosa GAUD. Bot. Voy. Uranie, 447. 1830.

Common on the mountains back of Honolulu. It does not grow in swamps, as the name would seem to indicate, but in woods which acquire considerable moisture from the frequent rains. A low bush, usually glabrous throughout; leaves lanceolate, acute at each end, bright green above, pale beneath, sharply serrate. Among the specimens are some which appear to be Hillebrand's var. *alnifolia.* He describes it as "young shoots and inflorescence hirsute with dark ferruginous hairs. Leaves rounded at the base, the strong ribs and veins pubescent." The leaves in these specimens are not rounded at the base, but the other characters are the same.

May to November (2268).

Cyrtandra pickeringii A. GRAY. Proc. Am. Acad. 5: 350. 1862.

A few specimens were collected on Tantalus which are referable to this species. They were growing with *C. cordifolia,* but seem to have the characters of the species mentioned above, provided that Wawra's *C. honoluluensis* is not distinct from *C. pickeringii.* In some respects they answer better to the description of Wawra's plant. The inflorescence, young branches, and under sides of the leaves are clothed with yellow hairs.

April 11 (2113); original locality, "mountains of Oahu."

Cyrtandra wawrai C. B. CLARKE, in DC. Monog. Phan. 5: 228. 1883.

Cyrtandra peltata WAWRA, Flora (II) **30**: 565. 1872, not Jacq.
Cyrtandra wawrae HILLEBR. Fl. Haw. Is. 328. 1888.

Described by both Wawra and Hillebrand as a branching shrub. In no case have I seen it branching. It is not uncommon about Hanapepe Falls, and in wet woods along the Wahiawa river, Kauai. The large, peltately affixed leaves are crowded at the summit of the stem, which is ascending or erect, and rather fleshy. The inflorescence and under sides of the leaves are covered with a soft wool, which feels very much like fine wool recently taken from a sheep.

June 24 (2437); original locality, "Kauai, wasser fall von Hanalei."

MYOPORINACEAE.

MYOPORUM Banks & Sol.; Forst. f. Prodr. 44. 1786.

Myoporum sandwicense (A. DC.) A. Gray. Proc. Am. Acad. 6: 52. 1863.

Polycoelium Sandwicense A. DC. Prodr. **11**: 706. 1847.

In this species, the general order of things is reversed, for it is said to be "a tree 20 to 30 feet high, in the higher, shrubby in the lower regions." It is occasionally found in gulches on the lee side of Kauai, below the forest. The wood is fragrant when dry, and was used as a substitute for sandalwood after that had become almost exhausted.

PLANTAGINACEAE.

PLANTAGO L. Sp. Pl. 112. 1753.

Plantago lanceolata L. Sp. Pl. 113. 1753.

Not recorded by Hillebrand, but plentiful on open slopes of the lee side of Kauai, and also on the edge of the forest on the plateau above Waimea. It was not seen at elevations lower than 2000 feet.

June to September (2457); original locality, "in Europae campis sterilibus."

Plantago major L. Sp. Pl. 112. 1753.

Small forms of this species were collected along the road in Pauoa and Nuuanu valleys, Oahu. On the island of Hawaiii the "leaves attain large proportions, with petioles of 6–8′, while the spikes reach 1½–2 feet," according to Hillebrand.

May (2322); original locality, "in Europa ad vias."

Plantago princeps C. & S. Linnaea, **1**: 167. 1826.

My specimens, collected at the Nuuauu Pali, Oahu, agree very well with the description of this species as it was originally given, and besides, the type came from "inclosed valleys at the foot of the mountains, on the island of Oahu." Wawra's *P. princeps* var. *acaulis* Flora (II) **32**: 564, came from the Pali, and is hardly anything more than the typical plant. He appears to have based his determination not on the original description in Linnaea, but on the descriptions of Gaudichaud and Hooker & Arnott, who had *P. queliana* in view when they

wrote their descriptions, and not the plant described by Chamisso and Schlechtendahl.

April 23 (2198).

Plantago queleana GAUD. Bot. Voy. Uranie, 445 *pl. 50.* 1830.

Cited by Chamisso and Schlechtendahl in Lindaea, **1**: 168. 1826, "Gaudichaud ined." They say the plant was collected on mountain heights, and ask whether it may not be their *P. princeps.* All the descriptions show that *P. queliana* is not prostrate, but has an erect stem, but that there was uncertainty about its being simple. On the ridge west of the Hanapepe river, Kauai, at an elevation of 3000 feet, were collected specimens from plants with stems which were simple and almost an inch in diameter, up to a height of nearly four feet, at which point they sent out five candelabra-like branches, on the ends of which were borne thick clusters of linear lanceolate, long pointed leaves, and long, flowering spikes. It can readily be seen how the earlier botanists, who did not see the living plants, could not be certain about whether the plant branched or not, for only one of the five branches can be used in making a specimen, and even then part of it must be cut away, so as to make it small enough to go on an ordinary sized sheet of mounting paper. That this and the plant from the Pali, with such a great difference in habit and appearance, can belong to the same species, is hardly possible.

July 23 (2610).

RUBIACEAE.

BOBEA GAUD. Bot. Voy. Uranie, 473, *pl. 93.* 1830.

Bobea elatior GAUD. Bot. Voy. Uranie, 473, *pl. 93.* 1830.

A slender tree, twenty to thirty feet high, with spreading, grayish branches. The leaves are light green, glabrous, and drop off easily. Collected on the heights of Pauoa, back of Honolulu, where it is occasionally found. *Bobea* is a genus found only in the Hawaiian group.

October (2897).

Bobea mannii HILLEBR. Fl. Haw. Is. 173. 1888.

The type of this species is M. & B. 621, in the Gray Herbarium, Cambridge, Mass. Mann erroneously referred this number to *Bobea brevipes* A. Gray, being misled perhaps by the pubescence which is common to both species. It is not un-

common on the ridge west of the Hanapepe river, Kauai, and also in woods near the Wahiawa river. The type was collected in the neighborhood of Kealia and Waimea, which indicates that it must be scattered over the entire island of Kauai. The leaves have a reddish or brownish tinge, due to the pubescence on them.

July 4 (2498).

COFFEA L. Sp. Pl. 172. 1753.

Coffea arabica L. Sp. Pl, 172. 1753.

The coffee tree was introduced in 1823, and for a time its cultivation was carried on successfully, until the inroads of a fungus threatened to destroy all the trees, when the attention of the planters was directed to the raising of sugar cane. Of late years its culture has been revived, and "Kona" coffee is obtaining quite a reputation. A single tree was noticed in Hanapepe valley.

October 21 (2890); original locality, "in Arabia felice."

COPROSMA FORST. Char. Gen. 137, *pl. 69.* 1776.

Coprosma kauensis (A. GRAY.)

Coprosma pubens, var. *Kauensis* A. GRAY. Proc. Am. Acad. **4**: 49. 1860.

The short description of "drupis obovatis obtusissimis plurimis sessilibus in pedunculo communi," by Gray, is all right so far as it goes, but the plant in question is very different from specimens of *C. pubens* in the herbarium of Columbia University. My specimens are from a small tree, which is loosely branched above, the slender branches covered with whitish bark. The leaves are oblanceolate, attenuate into the petiole, and acute at the apex, two and a half inches in length, by nearly an inch in width, dull green above, gray pubescent beneath. Common on the plateau above Waimea, Kauai, and also on the ridge west of the Hanapepe river, at elevations of 3000 to 4000 feet. The fact that it is found on the northern island of Kauai is an argument in favor of its being distinct from *C. pubens,* a species which has never been found north of Molokai, according to Hillebrand, and the type came from Hawaii. Sometimes the leaves are almost glabrous underneath.

August (2681, 2776).

Coprosma longifolia A. GRAY, Proc. Am. Acad. **4**:48. 1860.

A small tree, ten to fifteen feet high, with slender trunk. It is glabrous throughout, and has ternate leaves, an unusual occurrence among the Hawaiian species. Said by Hillebrand to occur on Oahu, Hawaii and Kauai. Specimens were collected in young fruit, on the slopes of Konahuanui, Oahu, at 2500 feet elevation.

April 25 (2176); original locality, "Oahu, Sandwich islands."

Coprosma waimeae WAWRA, Flora, (II) **32**;327. 1874.

Under *Coprosma foliosa*, Hillebrand remarks as follows: "Here must also be placed the imperfectly described *C. Waimeae* Wawra, l. c. p. 327, from Halemanu, Kauai: 'drupis ternis in pedunculo axillari, plerumque geminato, petiolo sublongiore, subglobosis, cerasi fere magnitudine, calicis dentibus coronatis."' Had he quoted the description in full, instead of picking out a sentence here and there, we could easily see that it is not "imperfectly described," but well characterized, and as valid a species as there is any on the group. The following is Wawra's description in full: "Arbuscula ramulis gracilibus parce foliosis e basilate triangulari acuminatis glabris; floribus * * drupis ternis in pedunculo axillari plerumque geminato petiolo sublongiore, subglobosis pulposis pro genere majusculis. Biorgyalis a basi ramosa, ramulis erectis ligneis glabris internodiis elongatis. Folia 2–3 poll. lga ac pollice in universum latiora, oblonga vel obovata, obtusa vel breviter et obtuse acuminata-rotundata, basi in petiolum 2–3 lin. longum sensim vel saepius abrupte contracta, glabra. Stipulae coriaceae persistentes. Drupae auriantacae, singulae bractea suffultae, cerasi fere magnitudine. Cal. dentibus coronatae. Semina orbiculari-oblonga, 2 lin. longa subsemiglobosa."

In addition, there is the following remark in German, which I have translated: "Has of all the Hawaiian species the largest berries. Its stipules indicate an affinity with *C. foliosa.* In habit it resembles *C. rhynchocarpa.* It appears to stand pretty far apart from all hitherto known Hawaiian species of *Coprosma.*" It is a handsome species, and, as Wawra says, probably has the largest berries of any Hawaiian species. Collected at elevations of 3000 to 4000 feet, on the ridge west of the Hanapepe river, and on the plateau above Waimea, Kauai.

August to October (2751, 2815); original locality, "Kauai, gebiet von Halemanu."

GOULDIA A. Gray, Proc. Am. Acad. **4**: 310. 1860.

Gouldia arborescens (Wawra)

Gouldia sandwicensis, var. *a arborescens* Wawra, Flora (II) **32**: 276. 1874.

Gouldia macrocarpa Hillebr. Fl. Haw. Is. 170. 1888.

After the description of *G. macrocarpa*, Hillebrand says that it agrees "tolerably well with *G. sandwicensis*, var. *a*, Wawra, from Hanalei, Kauai." By comparing the two descriptions, very little difference is found. It is altogether probable that Hillebrand's specimen of *G. macrocarpa*, with obovate leaves from Mt. Kaala, Oahu, belong to *G. terminalis*, which also has very large fruit, but the Kauai specimens, collected by Knudsen, are likely the same as Wawra's var. *arborescens*. Specimens with both ovate and obovate leaves were collected near the Wahiawa river, Kauai, at an elevation of 2500 feet. A small tree, ten to twenty feet high. The fruit is almost again as large as in any of the other species, except that of *G. terminalis*, which, when fully developed, is about as large as that of *G. arborescens*.

July 15 (2566, 2568); original locality, "Kauai, Thal von Hanalei."

Gouldia coriacea (H. & A.) Hillebr. Fl. Haw. Is. 168. 1888.

Petesia? coriacea H. & A. Bot. Beechy, 85. 1832.

Gouldia sandwicensis, var. *coriacea* A. Gray, Proc. Am. Acad. **4**: 310. 1860.

Kadua affinis C. & S.; A. Gray, Proc. Am. Acad. **4**: 310. 1860.

Asa Gray, as cited above, makes Chamisso and Schlechtendahl the authors of a *Kadua affinis*. These botanists, in Linnaea, **4**: 164, after describing five species of *Kadua*, mention a sixth plant thus: "6. Kaduae affinis." Then follows a description of a plant collected on Oahu. It is pretty evident from the "Kaduae affinis," that they meant a plant related to *Kadua*, and did not intend to give it a specific name, as it was the custom in early days to mention plants of uncertain affinities in just this way. To cite a similar case: Walter, in Fl. Car. 102, under *Anonymos*, says "Kuhniae affinis," but in addition, gives to the plant the specific name of *pinnata*, or, in other words, *Anonymos pinnata*, a plant allied to *Kuhnia*.

It seems that there is no type of Gray's "*Gouldia Sandwicensis*." It is merely a mythical species, intended to represent any plant of the genus *Gouldia*, which may be found in the Hawaiian Islands. He based it upon the two species of

Hooker and Arnott, *Petesia? coriacea* and *Petesia? terminalis*, reducing them to varieties, and added a third variety—*hirtella*. *G. coriacea* is found in the mountains back of Honolulu, at elevations of 2,000 feet and more. My specimens are from dwarfed trees, and agree with specimens in the Bernice Pauahi Bishop Museum, which were collected by Mann & Brigham.

May 23 (2347).

Gouldia elongata n. sp. (*Plate LX.*)

Shrubby, with long and slender, drooping branches, these subherbaceous near the ends and sharply four angled, glabrous throughout; bark gray, smooth; leaves elliptical-lanceolate, slightly more contracted at the apex than at the base, two to three inches in length, an inch and a half in width, entire, midvein prominent, impressed above, veins not prominent; petioles stout, almost an inch in length; panicles terminal, or occasionally axillary, pyramidal, very large and loose, with three or four nodes, trichotomously decompound; pedicels slender, angled, five lines long; berries small, one line in diameter, bluish.

The type is 2606 in part, and was collected July 25, on the ridge between the Wahiawa and Hanapepe rivers, at an elevation of about 2,500 feet. It grew in wet, boggy woods, a large number of the slender, wand-like stems springing from a single clump. It is evidently part of Hillebrand's *Gouldia terminalis*, but is very different from true specimens of that species, which is probably confined to the island of Oahu, unless it can be proved that *G. arborescens* is merely a more arborescent form of it.

No. 2889, collected in the bog at the head of the Wahiawa river, must also be referred to *G. elongata*. These specimens are from a stouter bush, divaricately branched, and bearing much shorter panicles, with larger berries. The leaves are smaller and more obovate in shape, It is perhaps distinct, but appears to have more characters in common with this species than with any other.

Gouldia lanceolata (WAWRA).

Gouldia sandwicensis, var. c. *lanceolata* WAWRA, Flora (II) **32**: 277. 1874.

This is certainly a good species, perfectly distinct from either *G. coriacea* or *G. terminalis*, which are the only other species found on the mountains back of Honolulu. My specimens are from small trees about ten feet high, with slender

trunks, and rounded, branching tops. Wawra describes it as "arbuscula a basi ramosa, ramulis abbreviatis, novellis exceptis distortis et torulosis." His specimens were collected on Waiolani, Oahu, at an elevation of 3,000 feet, which would account for the difference in the growth of the trunk and branches, as everything is dwarfed and stunted at that elevation on the mountains of Oahu. The leaves are "coriacea lanceolata vel oblongo-lanceolata acuta in petiolum subsemipollicarem sensim acutata," as described. Specimens with both long and short corollas were collected on Konahuanui, at elevations of 2000 to 2500 feet.

April to May (2177, 2314, 2315).

Gouldia sambucina n. sp. (*Plate LXI.*)

A tree, fifteen to twenty feet high, glabrous throughout, freely branching above, the bark close, grayish; leaves large, elliptical-ovate, three to five inches long, two to three inches wide, dull green on both sides, coriaceous, entire, moderately pointed, rounded or somewhat narrowed at the base, midrib and veins prominent; petioles stout, usually an inch in length; stipules about three-sixteenths of an inch long, triangular or ovate, slender pointed; inflorescence usually terminal, pyramidal in shape, shorter than the leaves, the branches numerous, trichotomous; berries small, globular, a line in diameter.

Type number, 2879, collected at an elevation of 3500 feet, on the edge of the plateau above Waimea, Kauai. The fruiting clusters bear a marked resemblance to the common American elder, *Sambucus canadensis*, whence the specific name. Owing to a mistake, specimens were distributed under the name of "*Gouldia neriifolia* n. sp." To it are referred No. 2883, which is almost identical, and 2859, with considerably smaller, narrower leaves, which are inclined to be contracted at the base. The fruit clusters are smaller, and the peduncles and pedicels slightly pubescent. All three numbers were collected at the same place, near the edge of the plateau.

Gouldia terminalis (H. & A.) HILLEBR. Fl. Haw. Is. 169. 1888.

Petesia? terminalis H. & A. Bot. Beechy, 85. 1832.

Gouldia sandwicensis, var. *terminalis* A. GRAY, Proc. Am. Acad. **4**: 310. 1860.

Hillebrand certainly must have confused two species under this name, for his characters, "tall rambling, almost scandent shrub, the long virgate branches subherbaceous," clearly point to *Gouldia elongata*. In the herbarium of Columbia University,

are specimens from Dr. Gray, labeled "*Gouldia sandwicensis*, var. *terminalis*," which are identical with my 2301, collected on the heights of Pauoa, back of Honolulu. The original of Hooker and Arnott was also undoubtedly collected in this region. It is a much branched bush, five or six feet high, the young branches subherbaceous and *terete*, with obovate, oblong leaves, which are slightly pointed, narrowed but rounded at the base, three to four inches long, two inches or less in width; panicles terminal, shorter than the leaves, flowers tinged with purple. The fruit is large, bright blue. With the exception of *G. arborescens*, this species has the largest fruit of any species in the genus, at least any species which has so far been described. As indicated by Hillebrand, Wawra's *G. sandwicensis* vars. *suffruticosa* and *cordata* probably belong here.

KADUA C. & S. Linnaea, 4:160. 1829.

Kadua acuminata C. & S. Linnaea, 4:163. 1829.

Kadua petiolata A. GRAY, Proc. Am. Acad. 4:318. 1860.

A shrub, several feet high, with spreading branches. Collected on the steep slope on the Konahuanui side of the Nuuanu Pali, Oahu.

May 24 (2360); original locality, "in nemoribus Insulae O-Wahu."

Kadua cordata C. & S. Linnaea, 4:160. 1829.

Woody at the base, with weak, spreading, herbaceous branches. The leaves are ovate-lanceolate, on short petioles, and the specific name is not derived from their shape, as might be supposed, but from the ovate, cordate, foliaceous bracts which subtend the flower clusters. Abundant on Konahuanui, Oahu, at an elevation of 2500 feet, and also recorded from Kauai.

April to November (2181); original locality, "insula O-Wahu."

Kadua elatior (MANN)

Kadua cookiana, var. ? *elatior* MANN, Proc. Am. Acad. 7:172. 1867.

Specimens of my No. 2440 have been compared with M. & B 569, which is the type of var. *elatior*, and pronounced identical with it. Mann's plant was collected at Hanalei, Kauai, and mine near Hanapepe falls. The type of *K. cookiana* came from the island of Hawaii, and allowing for geographical range and differences in the plants, the Kauai plant is certainly worthy of specific rank.

To this species is also referred No. 2442, collected near the same place, but on a steep bank above the Hanapepe river, while the former grew near the water's edge. This differs in being a branching shrub, two or three feet high, with broader leaves on longer petioles. The calyx lobes are also shorter and broader. Were it not for the fact that forms intermediate between this and No. 2440 were noticed wherever the two occurred, I would not hesitate to describe it as a distinct species.

Kadua glomerata H. & A. Bot. Beechy, 85. 1832.

Hillebrand records this species from Oahu, but on the Waianae mountains only. We are not told on what part of Oahu, Lay & Coollie collected their specimens, but one would naturally suppose that they did the greater part of it in the neighborhood of Honolulu. My specimens were collected on Konahuanui, back of Honolulu, where it is plentiful at an elevation of 2500 feet. The herbàceous, hollow branches are usually four or five feet long and reclining. The slender tube of the corolla is almost an inch in length. As described by Hooker & Arnott, the calyx and corolla are both strongly pubescent, and "the teeth of the calyx are linear and very rigid"

November 2 (2907); probably from the original locality,

Kadua knudsenii HILLEBR. Fl. Haw. Is. 162. 1888.

No. 2606, in part, collected July 23, at the head of the valley opposite Gay & Robinson's Hanapepe valley house, Kauai. The plants were growing alongside of a small waterfall. The slender, almost vine-like branches were eight or ten feet long, and drooped over the bank. Specimens in both flower and fruit were obtained. The following is Hillebrand's description: "Branches slender, bilineate, the longest internode $2\frac{1}{2}'$. Stipules triangular. Upper leaves $3x1\frac{3}{4}$ inches, on petioles of 2 lines, broad oblong, shortly acuminate, rounded at the base, chartaceous, faintly puberulous beneath. Lowest floral leaf cordate, sessile, 1 inch, the uppermost very small, not over one line long. Panicle pyramidal, ample and open, 8 inches long, with six nodes, the lowest branches again ramifying divaricately with simple or compound cymes at their ends, the lateral flowers on pedicels of $1-1\frac{1}{2}$ lines; the ultimate bractlets linear-spatulate to dentiform, about $\frac{1}{2}$ line long. Calyx lobes ovate or lanceolate, shorter than their tube. Corolla glabrous, its tube 3 lines, the spreading lobes more than $\frac{1}{2}$ that length, with tips inflected in the bud. Anthers sagittate, sessile below the throat. Style $\frac{1}{2}$ as long as the tube, with linear lobes, hairy at the base."

This is the original No. 2606, and very much resembles *Gouldia elongata*, which was collected several days later, and included under this number, so much alike are they in appearance and habit when only superficially examined. Examination will show that it differs from the *Gouldia* in having terete stems, a capsule dehiscent at the apex, and an ovate, cordate, sessile floral leaf at the end of the first node. Several specimens were also collected at the base of the plateau above Waimea, not far from the original locality. The type was collected by Knudsen, on the west side of the Hanapepe river.

Kadua waimeae WAWRA, Flora (II) **32**: 264. 1874.

A glabrous shrub, branching above, the slender branches drooping; leaves sessile, with cordate, clasping base, ovate, shortly acuminate, one to two inches long. The specimens are rather old, and the leaves have turned dark in drying. Collected at an elevation of 2500 feet, on the ridge opposite Gay & Robinson's Hanapepe valley house, Kauai. Originally included under No. 2615.

July 23 (2615a); original locality, "Kauai, Wälder von Halemanu."

MORINDA L. Sp. Pl. 176. 1753.

Morinda citrifolia L. Sp. Pl. 176. 1753.

Occasional trees are found in Hanapepe valley, Kauai The fruit which is the size of an ordinary orange, is "insipid and very foetid when decaying," according to Hillebrand. It is a small tree, ten or fifteen feet high, with spreading branches, and large, ovate, pointed leaves.

August 14 (2716); original locality, "in India."

NERTERA BANKS & SOL.; GAERTN. Fr & Sem **1**: 124, *pl. 26*. 1788.

Nertera depressa BANKS & SOL.; GAERTN. Fr. & Sem. **1**: 124, *pl. 26, f. 1.* 1788.

Very common in wet woods, near the head of the Wahiawa river, Kauai, where it creeps over the ground and forms thick mats. The stems root at the nodes. Properly the flowers are terminal, but those of young and short branches have the appearance of being axillary.

August 12 (2702); original locality, "in regionibus antarcticus."

PAEDERIA L. Mant. 52. 1767.

Paederia foetida L. Mant. 52. 1767.

Very abundant in upper Nuuanu valley, Oahu. In many places the interlaced and twining stems cover grass and bushes completely. The tomentose flowers are pale lilac in color. Introduced about 1854.

October 29 (2893); original locality, "in India."

PLECTRONIA L. Mant. 52. 1767.

Plectronia odorata (FORST.) HILLEBR. Fl. Haw. Is. 175. 1888.

Coffea odorata FORST. f. Prodr. 16. 1786.

Common on the lee side of Kauai, up to an elevation of 2500 feet. Specimens were collected in Hanapepe valley, and in ravines above Waimea. The thick, dark green, glossy leaves, make it conspicuous on the hillsides and gulches. It is a tree ten to twenty feet high. Hillebrand cites "Benth. & Hook. Gen. Pl. 2:110," as the authors of *Plectronia odorata*, but in uniting *Canthium* with *Plectronia*, those botanists do not mention species, hence to them does not belong the credit of the combination, unless we grant that Hillebrand published it for them.

June to September (2445).

PSYCHOTRIA L. Syst. Ed. 10, 929. 1759.

Psychotria hexandra MANN, Proc. Am. Acad. 7:170. 1867.

Specimens collected at an elevation of about 3,500 feet, on the ridge west of the Hanapepe river, Kauai, seem to belong to this species, although in some points they do not agree with the description as given by Mann and Hillebrand. The leaves are acute at both ends, as described, but are not pale beneath. Instead, they are more or less provided with brownish hair and scales. The anthers are oblong, slightly narrowed at the apex, but not acute, and not contracted at the base. A small tree, fifteen feet high, with spreading branches. Perhaps a distinct species.

August 6 (2680); original locality, "on the mountains above Waimea, Kauai."

Psychotria hirta (WAWRA)

Collected in flower only, at an elevation of 4,000 feet, on the plateau above Waimea, Kauai. A slender tree, fifteen feet high, with obovate, abruptly pointed leaves, which are pubescent underneath on the veins and midrib, and also brown scaly in the spaces between the veins. The flowers are large, lemon yellow, but the cymes are not specially contracted, although they are few flowered.

October 12 (2876); original locality, "Gebirgs walder von Halemanu."

RICHARDIA L. Sp. Pl. 330. 1753.

Richardia scabra L. Sp. Pl. 330. 1753.

Common in cane fields on the lee side of Kauai, and also in pastures. Specimens were collected near Hanapepe, in a cane field, and on the plateau above Waimea, where it was growing on the edge of the woods.

July to September (2564); original locality, "in Vera Cruce."

STRAUSSIA A. GRAY, Proc. Am, Acad. 4: 42. 1860.

It seems that Nuttall had recognized that these plants belonged to an undescribed genus, and has labeled his specimens *Apionema*, with three species, *obovata*, *penduliflora* and *sulcata*. Unfortunately he never published a description of them, and Dr. Gray did not take up his name, but substituted *Straussia* in its stead.

Straussia kaduana (C. & S.) A. GRAY, Proc. Am. Acad. 4:43. 1860.

Coffea kaduana C. & S. Linnaea, **4**: 33. 1829.

A variable species, one number of which (2193) I distributed as "*Straussia parviflora* n. sp." It is merely a small leaved form, collected on the steep slopes of the Nuuanu Pali, Oahu. On the slopes of Konahuanui, at an elevation of 2,500 feet, another form (2350) was collected. This has longer leaves and larger fruit. Another form from the head of Kalihi valley (2333), has long, erect, pubescent peduncles. The length of the corolla tube is variable in this species, but it is always supposed to be smooth in the throat. Though the leaves are variable, they are more or less obovate and short peticled in all cases, as in the original description: "Folia breviter petiolata, firmia, opaca, cuneato-obovata, angulo apicali obtuso,

supra plana, nervo medio, quam crassus latiori." The original locality is "in nemorosis montium Insulae O-Wahu."

Straussia mariniana (C. & S.) A. GRAY, Proc. Am. Acad. 4: 43. 1860.

Coffea mariniana C. & S. Linnaea, **4**: 35. 1829.

This species seems sufficiently distinct from any of the others by the leaf shape alone, although Mann, in Proc. Am. Acad. 7: 170, says "the only characters upon which this species can be kept distinct from the first (*kaduana*) are, so far as the specimens now show the slightly longer tube of the corolla, which is bearded within." It is very likely that some of the specimens which Mann cites are not of this species, but belong to another. The original is clear enough, and one who has observed these plants in the field, should have no great difficulty in deciding to which of the two species enumerated above his specimens belong. The original description says: "Folia in apicibus conferta, elliptica, utrinque acuta, apice tamen obtusiuscula * * * maxima 3½ poll. longa, 1½ poll. lata, petiolo ad summum semipollicari, lamina decurrente marginata." My No. 2267, from the slopes of Konahuanui, back of Honolulu, has elliptical-lanceolate leaves, acute at both ends. The flowering panicles are erect. On Kauai it is common in damp woods on the lee side of the island up to an elevation of 4000 feet. Here it is larger in every way than on Oahu, and is not typical. The tree is larger, the leaves are broader and somewhat longer, but preserve the same general shape that they have in the Oahu plant. Petioles two or three times longer than in *S. kaduana*, is also a constant character in this species. As the types of both species came from Oahu, it is only there that we may expect to find anything like the originals, and specimens from other islands can merely be referred to one or the other with more or less uncertainty, especially since it is a recognized fact that outside of the introduced species, there are very few species common to two or more of the islands.

July to September (2267, 2565); original locality, "in nemorosis montium O-Wahu."

Straussia psychotrioides n. sp. (*Plate LXII.*)

A small tree, ten to fifteen feet high, branching above, the branches loose and spreading, with the young parts more or less angled; bark gray, somewhat ridged; leaves opposite, usually divaricate, or sometimes reflexed, obovate oblong, the

apex rounded, but often bluntly pointed, gradually narrowed at the base, three and a half inches long, one and a fourth inches wide, coriaceous but thin, entire, the margins slightly inrolled, glabrous and light green on the upper side, brown scaly and shortly pubescent beneath between the veins, midrib and veins yellowish, prominent, especially the midrib; average length of petioles six-sixteenths of an inch; stipules broadly ovate or almost orbicular, not narrowed at the base; peduncles erect, an inch and a quarter in length; inflorescence composed of two or three whorls, three rays springing from each node, each of the lower rays two-flowered, the flowers very shortly pedicelled, the upper rays one-flowered, much longer pedicelled; flowers white, with very short tube, and spreading lobes; fruit obovate, four lines high, slightly swollen at the base, crowned by the short calyx lobes.

The type is No. 2885, collected at an elevation of 3500 feet, along the edge of the plateau above Waimea, Kauai. Trees of this species were also seen on the ridges west of the Hanapepe river, but specimens were not collected. Unfortunately none of the specimens now at hand show the flowers. It is remarkable as having the largest flowers of any known species in the genus. The corolla is about five lines long, with a tube hardly one-fourth the length of the spreading lobes. The stamens are exserted. In the living plant, the leaves, too, are peculiar. They are thin, and the prominent midrib and veins help to give them an appearance which is hardly describable. They have a grayish, semi-transparent aspect, which is not at all brought out in dried specimens. The persistent calyx lobes which crown the fruit, though small, are larger than is usual in *Straussia*. Althgether, there is a decided leaning toward *Psychotria*.

Straussia pubiflora n. sp. (*Plate LXIII.*)

A small tree, fifteen to twenty feet high, with slender trunk. branching above; bark gray, roughened; young branches slender, nodose, the growing parts somewhat quadrangular or flattened; leaves opposite, obovate oblong, two to three and a half inches long, one and a half inches wide, thin, glabrous, entire, slightly contracted at the end, light green above, darker beneath, midrib and veins prominent; petioles a half inch or more in length; stipules ovate, rounded, two lines long; panicles pendulous on puberulous peduncles of two inches in length; inflorescence puberulous, composed of three whorls, each, except

the terminal one, bearing four rays, each ray three to five flowered; calyx a line long, with inconspicuous lobes; flowers white, three lines long, the tube pubescent, lobes spreading, as long as the tube, oblong, obtuse; stamens short, slightly exserted, inserted at the junction of the corolla lobes with the tube; filaments not longer than the anthers, somewhat pubescent; style not exserted, two lobed; ovary glabrous.

The type is No. 2300, collected May 13th, on the heights of Pauoa, Oahu. It is possible that this may be Nuttall's *Apionema penduliflora*, published by Dr. Gray as a synonym of *Straussia kaduana*. There is apparently no way of determining this, except by comparing it with Nuttall's specimen in herb. Hooker. It seems to be Hillebrand's *Straussia kaduana* var. *gamma* from Pauoa and Makiki. To this species must also be referred No. 2210, which differs in having broader leaves on shorter petioles. In texture, though, they are the same as those of No. 2300. It was also collected on the heights of Pauoa.

LOBELIACEAE.

CLERMONTIA GAUD. Bot. Voy. Uranie, 459, *pl. 71–73.* 1830.

Clermontia clermontioides (GAUD.)

Delissea clermontioides GAUD. in Mann, Proc. Am. Acad. **7**: 178. 1867.

Clermontia gaudichaudii HILLEBR. Fl. Haw. Is. 243. 1888.

Figured by Gaudichaud, but not described, in the atlas of the Botany of the Voyage of the Bonite, as plate 47. The first description appears to have been drawn up by Mann, and credited to Gaudichaud as cited above. It occurs at intervals in wet woods near the source of the Wahiawa river, Kauai. A much branched bush, eight or ten feet high, with thick, pale green, elliptical-oblong, pointed, crenulate leaves. The yellow fruit is almost an inch in diameter.

August 12 (2704).

Clermontia kakeana MEYEN, Reise, 358. 1843.

Clermontia macrophylla NUTT. Trans. Am. Phil. Soc. (II) **8**: 251. 1843.

Clermontia macrocarpa GAUD. Bot. Voy. Bon. *pl. 49*, without description.

Hillebrand takes up the specific name *macrocarpa*, and remarks as follows: "Meyen's name is older than Gaudichaud's, but, as it was published without description, and the word

Kake is the native rendering of the English name Jack, probably adopted by the travelers guide, I forbear from introducing it." Meyen's name was published with description, as cited above, and also in Walp. Rep. Bot. Syst. 2: 708. 1843, where it is given thus: "CL. KAKEANA Meyen, mss. in Hb. Regio Berolin," followed by a description. It is possible that *C. macrophylla* Nutt., may have precedence of a few months, but it would be a hard matter to find out definitely. At any rate, it was described twice in 1843 under the name *kakeana*, and *C. macrocarpa* Gaud., is the name without a description, Hillebrand's statement to the contrary. The species is plentiful on the heights of Pauoa and Tantalus, above Honolulu. A small tree, eight or ten feet high, with branching top and light green leaves, six to eight inches in length. They are elliptical-oblong, rather thin, finely serrate, puberulous beneath. The flowere are large, nearly two inches long, and a half inch broad, yellow green, slightly curved. The anthers are purplish.

April 11 (2059); original locality, Oahu.

Clermontia oblongifolia GAUD. Bot. Voy. Uranie, 459, *pl. 71.* 1830.

A small tree, fifteen to twenty feet high, with straight trunk and spreading top; leaves oblong, on long petioles, thick and leathery, serrate; flowers dull green, tinged with purple, over two inches in length, strongly curved. Collected on Konahuanui, Oahu, at 2500 feet elevation.

May 2 (2239).

Clermontia persicaefolia GAUD. Bot. Voy. Uranie, *pl. 72.* 1830.

A branching bush, five or six feet high. The leaves and flowers are shaped like those of *C. oblongifolia*, but the former are much narrower and shorter, on shorter petioles, with different serration, and are brighter green and shining above, instead of dull. The flowers are more numerous, smaller, less curved and almost white. Collected at an elevation of 2500 feet, on Waiolani, back of Honolulu.

June 6 (2391).

CYANEA GAUD. Bot. Voy. Uranie, 457, *pl. 75.* 1830.

Cyanea coriacea (A. GRAY) HILLEBR. Fl. Haw. Is. 254. 1888.

Delissea coriacea A. GRAY, Proc. Am. Acad. **5**: 147. 1862.

This species is abundant along the banks of the Hanapepe and Wahiawa rivers, and probably also along the Waimea and its

tributaries, since Hillebrand records it from "Waimea, at elevations of about 2000 feet." He attributes to it the erroneous character of "branching shrub." It must be remembered that Hillebrand personally knew nothing about the vegetation of Kauai. He received all of his Kauai specimens from Mr. Vladmir Knudsen, of Waimea, who owns a large tract of land west of the Waimea river. The plant in question is simple, with a trunk five to ten feet high, an inch or two in diameter, and topped by a dense cluster of long, obovate-oblong leaves on long petioles. The flowers are long-peduncled, numerous in the axils of the leaves. They are about an inch in length, almost white, or purple tinged, somewhat curved. It is figured as *Plate LXIV*, which shows only a small portion of the top of a plant

Cyanea hirtella (MANN) HILLEBR. Fl. Haw. Is. 255. 1888.

Delissea hirtella MANN, Proc. Am. Acad. **7**: 179. 1867.

In making his key for this genus, Hillebrand appears to have paid little attention to the original descriptions. To this species he attributes "calcyine lobes nearly as long as the tube." Mann's description is plainly contrary to this, for he says "lobis calycis lanceolatis ovario multo brevioribus." The chances are that Hillebrand had an entirely different plant. At an elevation of 4000 feet, on the plateau above Waimea, Kauai, I collected specimens which Mr. Fernald has kindly compared with Mann's type, and pronounced them identical. It is described as "a large branching shrub, 20 feet high, hirsute with short rusty hairs." The leaves are "oblanceolatis utrinque acuminatis crebre serrulatis, supra glabris petiolatis." My specimens are from branching shrubs, eight to ten feet high, which grew only on the banks of a forest stream. The leaves are four to six inches long, on petioles of an inch or more in length. The specimens are in fruit only.

August 30 (2769); from the original locality, "mountains above Waimea, Kauai."

Cyanea leptostegia A. GRAY, Proc. Am. Acad. **5**: 149. 1862.

The trunk of this species is usually about twenty feet high, although much taller ones are sometimes found. It is three inches or more in diameter, hollow, but here and there closed by a white membrane, simple, and topped by a dense, round crown of leaves, which are slightly drooping. The flowers are crowded at the bases of the lower leaves, and from the remains

of old ones, it would seem that both corolla and staminal column are somewhat pubescent. The juice is yellowish and thick. Collected at the type locality, "upper edge of the forest, near the tabular summit of Kauai."

September 9 (2793).

Cyanea longifolia n. n.

Delissea arborea MANN, Proc. Am. Acad. **7**: 180. 1867, not Presl. 1836.

Cyanea arborea HILLEBR. Fl. Haw. Is. 261. 1888.

The earlier *Delissea arborea* of Presl invalidates Mann's later one, and I have assigned to it the name given above. The leaves are described as being two feet long.

Cyanea spathulata (HILLEBR.)

Cyanea coriacea, var. *spathulata* HILLEBR. Fl. Haw. Is. 254. 1888.

This is described as having "leaves narrowly spathulate, 4–6 x $\frac{3}{4}$–1 inch, on petioles of $\frac{1}{2}$–1 $\frac{1}{2}$ inches, coriaceous, slightly pubescent underneath along the prominent rib and veins." My 2768, collected at an elevation of 4000 feet, above Waimea, Kauai, seems to belong here. The specimens came from a shrub eight or ten feet high, branching above, the branches slender, and often curved at the ends. It grew along the banks of a forest stream on the plateau. The calyx and corolla are the same as those of *C. coriacea*, and the leaves are of the same general shape, but much narrower, more acute, and on petioles very much shorter. In that species the racemes, although on long peduncles, are only as long as the petioles, while in this theyare half the length of the leaves. The habit of the two plants is also different. *C. coriacea* never branches, except in rare cases where the stem has been broken or injured, while *C. spathulata* always branches, and grows at much higher elevations, and in deep forests, instead of along river banks in open places on the edge of the woods. The type came from the west side of the Waimea river, "at heights of 4000 feet." *C. coriacea* has not been found higher than 2000 feet, or, at most, 2500 feet, along the Wahiawa. Figured as Plate LXV, which shows a single branch.

August 30 (2768).

Cyanea sylvestris n. sp. (*Plate LXVI.*)

An unbranched shrub, four to eight feet high, with a trunk one to two inches in diameter; leaves large, disposed at the summit of the erect stem, lanceolate or ovate-lanceolate, twelve

to fourteen inches long, three to four inches wide, thin, glabrous, light green and shining above, paler beneath, serrulate, acute, narrowing below into a stout petiole, veins prominent on both sides, the midrib raised on the upper side, flat and broad on the lower side; petioles one to two inches long; inflorescence somewhat pubescent with short, brownish hairs; flowers mostly in the axils of the upper leaves; peduncles shorter than the petioles, several flowered; calyx somewhat campanulate, the lobes narrowly lanceolate, much shorter than the tube; corolla nearly two inches in length, slender, curved, purple; staminal column glabrous; berry yellow, obovate, nearly three-fourths of an inch in length, with a diameter of nearly a half inch, crowned by the persistent style; seeds brown, very glossy.

The type is No. 2691, collected in wet woods near the Wahiawa river, Kauai, at elevations of 2,500 to 3,000 feet. It is always found back in the forest, never in open places, and is rather common. There is a possibility that it may be the same as *Cyanea recta* (Wawra) Hillebrand, but does not quite agree with the description of that species. Nearly all of my specimens were in fruit, but several had unopened flowers, one of which is shown in the plate, and a few were found which had old, withered flowers attached. The fruit is larger than that of any other *Cyanea* which I have seen.

To this species is also referred No. 2494 of which a few specimens were collected on the ridge west of the Hanapepe river. They are in neither flower or fruit, but merely have undeveloped buds.

DELISSEA GAUD. Bot. Voy. Uranie, 457, *pl. 76–78.* 1830.

Delissea rhytidosperma MANN, Proc. Am. Acad. **7**: 180. 1867.

Delissea kealiae WAWRA, Flora (II) **31**: 10. 1873.

It is possible that Wawra's species is distinct from Mann's and in that case my specimens are not *D. rhytidosperma*, but *D. kealiae*, for they were collected on the east side of the Hanapepe river in wet woods near the source of the Wahiawa, not many miles from the place where Wawra collected his type. Mann's type, on the contrary, came from the "mountains above Waimea, Kauai," in what is practically a different floral area, neither did I see this same plant above Waimea.

July to October (2487).

Delissea undulata GAUD. Bot. Voy. Uranie, 457, *pl.* 78. 1830.

As stated by Dr. Gray, in Proc. Am. Acad. 5:148, *D. subcordata* seems to be nothing but a form of this species, for, as he remarks, "leaves with the base subcordate, obtuse, or acute, being found on the same stem." Scattered plants may be found on the grassy slopes west of the Hanapepe river, Kauai, at elevations of about 2000 feet. On an individual plant may be found young leaves which answer to the description of *D. undulata*, while the old leaves agree with description of *D. subcordata*. The blades of the mature leaves are often seven inches long, with petioles six inches long. The slender, greenish corollas are curved.

June 25 (2430).

LOBELIA L. Sp. Pl. 929. 1753.

Lobelia kauaensis (A. GRAY)

Lobelia gaudichaudii var. *Kauaensis* A, GRAY, Proc. Am. Acad. 5:150. 1862.

Had Dr. Gray seen these two plants in the living state, he certainly would not have considered the one a mere form of the other, worthy of varietal rank only. My specimens were collected in the bog at the head of the Wahiawa river. The trunk, three or four inches in diameter, is covered with leaf scars, and rises to a height of five or six feet, when it sends out five candelabra-like branches of nearly two feet in length. The upper half of these branches is covered with very large, curved flowers, two inches or more in length, usually of a pale purple or pink, with deep purple stripes, and on pedicels of an inch in length. The calyx is slightly over a half inch in length, the lobes oblong, blunt, longer than the tube. The oblong-lanceolate leaves are a foot and more in length, sessile, with a broad base, acute. Those on the branches are of the same shape, but gradually decrease in size, until just below the flowers they are only an inch or two long.

October 19 (2888).

I saw *L. gaudichaudii* on the summit of Konahuanui, but it was just out of flower. It is a species of very different growth. The stems are simple, as a rule, and only an inch or two in diameter. The original description of it in DC. Prodr. 7:384, calls for "planta 3-pedalis medulla farcta. Folia 3–4 poll. longa, 6–12 lin. lata, erectiuscula." The corolla is described as only three times longer than the calyx.

Lobelia tortuosa n. sp. *(Plate LXVII).*

Woody; stems clustered from a thick mass of roots, the older ones almost an inch in diameter at the base, gnarled and twisted, the young flowering and leaf-bearing ends ascending and sparingly branching, closely studded with leaf scars; leaves narrowly lanceolate-oblong, slightly cyathiform, acuminate at the apex, tapering at the base into a short winged petiole, six inches in length, three-fourths of an inch wide, light green and somewhat pubescent above, pale and densely soft pubescent beneath, with prominent midveins; flowering branch angled; pedicels a half inch in length, horizontal for half their length, then twisted and curved upward, each subtended by a subulate bract, tomentose; calyx shallow cup-shaped, truncate, shortly pubescent, the lobes linear, almost as long as the tube; corolla an inch and a half in length, garnet colored, somewhat contracted near the middle, pubescent, lobes revolute; stamens glabrous, or occasionally with a few scattered hairs; lower anthers tufted at the ends with white hairs; style with a pubescent ring at the base of the stigma.

The type is No. 2443, collected on perpendicular cliffs along the Hanapepe river, Kauai. The thick, knotted mass of roots protrude from crevices of the rocks, and from them spring the at first declined and twisted, finally ascending, sparingly branched stems. Its nearest relative seems to be *L. neriifolia* A. Gray, from east Maui. Mr. Fernald has compared the two, and finds them quite distinct.

ROLLANDIA GAUD. Bot. Voy. Uranie, 458, *pl. 74.* 1830.

Rollandia lanceolata GAUD. Bot. Voy. Uranie, 458, *pl. 74.* 1830.

There seems to be some doubt as to whether *R. lanceolata* is the proper name since Dr. Gray says it is quoted as *R. montana* on the plate. Hillebrand has recorded a number of forms and varieties. To one of these belong my specimens, collected on the lower slopes of Konahuanui. The stems are simple, smooth, nearly an inch in diameter, inclined to be decumbent. The leaves are often two feet long, acute at each end. The flowers are red-purple, over two inches in length, curved. *Rollandia* is a genus which is found only on the island of Oahu.

April 25 (2184).

GOODENIACEAE.

SCAEVOLA L. Mant. 145. 1771.

Scaevola chamissoniana GAUD. Bot. Voy. Uranie, 461, *pl. 82.* 1830.

A common and variable species. A shrub, six to ten feet high, freely branching, the flowers white, tinged with purple. No. 2052, collected at an elevation of 2,000 feet on Tantalus, back of Honolulu, had rather narrow, oblanceolate leaves, and short cymes. No. 2340, collected at the head of Kalihi valley, Oahu, has broader leaves, more abruptly contracted below, and longer cymes. No. 2569, collected at an elevation of 2,500 feet, near the Wahiawa river, Kauai, has broad leaves on longer petioles, and densely flowered cymes, which are much branched, and extend beyond the leaves. The leaves in all three forms are serrate, and more or less acuminate.

Scaevola glabra H. & A. Bot. Beechy, 89. 1832.

This seems to be unlike the other species, and perhaps is generically distinct. It was collected in fruit, on the plateau above Waimea, Kauai, where it grew far back in wet woods. The linear, persistent calyx lobes are half the length of the fruit. The yellow corolla is thick and leathery, and, judging from illustrations, is very different from the corollas of other Hawaiian species.

September 15 (2806); original locality, Oahu.

Scaevola koenigii VAHL. Symb. Bot. **3**: 36. 1794.

Collected along the seashore at Mana and Waimea, Kauai. Hillebrand, who calls it *Scaevola lobelia* L., describes it as "an erect shrub, 4–6 ft. high, extensively branching from the base, the succulent branches, leaves, and inflorescence generally silky pubescent, rarely glabrate." Not one of the bushes seen at Mana or Waimea were erect, but decumbent and much branched, the branches somewhat ascending. The berries are white.

August to October (2730).

Scaevola mollis H. & A. Bot. Beechy, 89. 1832.

Collected on Konahuanui, Oahu, at an elevation of 2500 feet; The lanceolate leaves are thick, dark green above, densely tomentose beneath. The flowers are pale purple.

May 23 (2346); original locality, Oahu.

Scaevola procera HILLEBR. Fl. Haw. Is. 268. 1888.

Concerning this species Hillebrand says: "As to shape of leaves and color of flowers, much like *S. Chamissoniana*, but in the inflorescence and hairiness it approaches *S. mollis*. It is Remy's no. 311." No. 2837, collected on the plateau above Waimea, Kauai, answers well to the description of this species, except the hairiness of the leaves, which are thin, and only slightly pubescent. The cymes are very short, usually not over an inch in length, and many of them scattered on the bare stems below the leaves. No. 2617, collected on the ridge opposite Gay & Robinsons Hanapepe valley house, has narrower and slightly thicker leaves, which are entire, or somewhat obscurely serrate. On these specimens the pubescence is more manifest, and the cymes are more crowded, in the axils of the upper leaves. It was collected at an elevation of about 2,800 feet.

July to September (2617, 2837).

COMPOSITAE.

ACANTHOSPERMUM SCHRANK, Pl. Rar. Hort. Monac. *pl. 53.* 1819.

Acanthospermum brasilum SCHRANK, Pl. Rar. Hort. Monac. 2:53. 1819.

Hillebrand records this species as occurring only on Kauai. It is plentiful there on pasture lands from sea level to 4,000 feet, but is also now found along the road in Nuuanu valley, Oahu.

March 29 (2030).

ADENOSTEMMA FORST. Char. Gen. 90. 1776.

Adenostemma viscosum FORST. Char. Gen. 90. 1776.

A species which occurs in wet woods at elevations of 1,200 to 3,000 feet. Specimens were collected in Kalibi valley, Oahu, and on the heights of Pauoa. An herbaceous plant, with reclining or ascending stems.

May 20 (2339).

AGERATUM L. Sp. Pl. 839. 1753.

Ageratum conyzoides L. Sp. Pl. 839. 1753.

A common weed about the streets of Honolulu, and on the lower slopes near the city. Said to be diffused over the whole group.

March 25 (1999); original locality, "in America."

APHANOPAPPUS Endl. Gen. Pl. Suppl. 2, 43. 1842.

[**Schizophyllum** Nutt. Trans. Am. Phil. Soc. (II) **7**:452. 1841, not Fries.]

The following is Nutall's original description of this genus, the type of which is *Schizophyllum micranthum*, collected on "the island of Atooi (Kauai) in shady woods, near Koloa." "Capitulum few flowered, heterogamous. Rays feminine, two or three bidentate; discal florets subcampanulate, five toothed. Involucrum small, oblong, imbricate, about five leaved. Receptacle paleaceous, the scales resembling the involucrum, embracing. Discal stigmas hirsute, with a slender conic apex. Achenia of the ray turgid, indurated, three or four sided, obtuse and turbinate, those of the disk abortive, subquadrangular. Pappus none, or a slight vestige of an aristate crown. An heraceous plant of the Sandwich Islands, with diffusely trailing, oppositely branching, quadrangular stems, and opposite pseudo bipinnate leaves. Flowers yellow, usually terminal in threes, nearly sessile."

Aphanopappus micranthus (Nutt.)

Schizophyllum micranthum Nutt. Trans. Am. Phil. Soc. (II) **7**: 452. 1841.

Aphanopappus nuttallii Walp. Rep. **2**: 620. 1843.

Lipochaeta micrantha A. Gray, Proc. Am. Acad. **5**: 131, 1862.

The leaves of this species are somewhat variable, and one who sees a branch with young leaves only, might be tempted to suppose that it is a distinct plant from one which has older leaves. The stems are usually five or six feet long, weak and somewhat climbing. The leaves are lanceolate, twice or thrice pinnately parted or divided. The inconspicuous, pale yellow flowers are easily overlooked, as they are almost sessile, and hidden by the numerous, crowded leaves. It is plentiful in Hanapepe valley, Kauai, on moist, shaded banks, and was also collected above Waimea, at the base of the plateau.

June to September (2439).

ARTEMISIA L. Sp. Pl. 845. 1753.

Artemisia australis LESS. Linnaea **6**: 522. 1831.

Common at the Nuuanu Pali, Oahu, where it grows on the edge of the precipice, and also in crevices on the faces of perpendicular rocks, at an elevation of 1400 feet. It was found in similar situations on the edge of the plateau above Waimea, Kauai. Hillebrand says that it grows "only on the highest ridges."

May to September (2364); original locality, "in O-Wahu Sandvicensium."

BIDENS L. Sp. Pl. 831. 1753.

Bidens pilosa L. Sp. Pl. 832. 1753.

A common weed on Oahu, from the slopes of Punchbowl to the heights of Tantalus. It is common also on Kauai, ranging from Hanapepe valley to the edge of the plateau above Waimea.

April to September (2090); original locality, "in America."

CAMPYLOTHECA CASS. Dict. Sci. Nat. 51: 476. 1827.

Campylotheca cosmoides (A. GRAY) HILLEBR. Fl. Haw. Is. 213. 1888.

Coreopsis cosmoides A. GRAY, Proc. Am. Acad. **5**: 126. 1862.

Ascending, five to eight feet high, the herbaceous branches spreading and somewhat climbing; leaves dark green glabrous; flowers nodding, on peduncles two or three inches in length. It is plentiful in ravines on the edge of the plateau above Waimea, Kauai. Hillebrand mentions it from Kauai only, but Gray records the type as having been collected on "Hawaii."

September 2 (2791).

Campylotheca mutica (NUTT.)

Bidens mutica NUTT. Trans. Am. Phil. Soc. (II) **7**: 368. 1841.

Coreopsis (Campylotheca) macrocarpa A. GRAY, Proc. Am. Acad. **5**: 126. 1862.

Campylotheca macrocarpa HILLEBR. Fl. Haw. Is. 214. 1888.

Speaking of this species, Hillebrand says "Nuttal's name has precedence, but is inappropriate on account of the strongly barb awned varieties. It is rather unfortunate that a name should be inappriate for later discovered forms, but it is more unfortunate that the original name should be discarded for what appears to be more appropriate. My No. 1988, collected

at the Nuuanu Pali, appears to be the same as Nuttall's plant, which was probably also collected at the Pali. It is described as "less than a foot high." My specimens are ten to fifteen inches high, branched. The leaves are three foliolate, the lateral divisions sessile and oblique, the terminal ones petioled and larger. No. 2894, collected at the Pali, but some two or three hundred feet higher, on the steep slopes, is perhaps Nuttall's *Bidens gracilis*, as it answers very well to his description. It is taller, and more slender, with narrower and thinner leaves, but does not seem to be distinct from *C. mutica*.

March to October (1988, 2894); probably from the original locality.

Campylotheca sandwicensis (Less.) Hillebr. Fl. Haw. Is. 214. 1888.

Bidens sandwicensis Less. Linnaea, **6**: 508. 1831.

Gray evidently confused this with *C. mutica*, as the two are somewhat similar in appearance, especially when not seen in the living state. This species, however, is much taller, three to five feet high, with larger flowers. It is plentiful on Konahuanui, Oahu, at an elevation of 2500 feet, and appears to be confined to the forest, while *C. mutica* flourishes on open, grassy slopes.

November 2 (2901); original locality, "in O-Wahu."

CENTAUREA L. Sp. Pl. 909. 1753.

Centaurea melitensis L. Sp. Pl. 917. 1753.

Abundant in a grassy field at Waikiki, Oahu. An annual, about two feet high, with small yellow heads.

May 9 (2287); original locality, "in Melita."

DUBAUTIA Gaud. Bot. Voy. Uranie, 469, *pl. 84.* 1830.

Dubautia laevigata A. Gray, Proc. Am. Acad. 5: 135. 1862.

Originally described from a specimen out of flower, but quite distinct from *D. plantaginea*, which it resembles. A shrub, six to eight feet high, with branching top. The bright green, glossy leaves are narrowed into margined, clasping petioles. The panicle, however, is pubescent, and the flowers are yellow. Collected at an elevation of 3,000 feet, on the ridge west of the Hanapepe river, Kauai. It is not plentiful there, and very few plants were in bloom.

July 23 (2616); original locality, "Kauai Sandwich Islands."

Dubautia laxa H. & A. Bot. Beechy, 87. 1832.

On Konahuanui, Oahu, this species is not uncommon from an elevation of 2,500 feet to the summit. On and near the summit it is very plentiful, the broad as well as the narrow leaved forms being found side by side. It is smaller and more bushy than *D. plantaginea*, but this is due to the greater elevation, and the fact that it grows only within the limit of scrub vegetation. The inflorescence is hispid, and the flowers purple.

November 2 (2902); original locality, Oahu.

Dubautia knudsenii HILLEBR. Fl. Haw. Is. 223. 1888.

A branched shrub, about six feet high. The branches are slender, glabrous, brownish, and spreading. The leaves are obovate, thin, glabrous, cuspidate, serrate. In my specimens the corymbose inflorescence is not quite as long as the leaves, and drooping, the latter fact not noted by Hillebrand. Collected at an elevation of 4,000 feet, on the plateau above Waimea, Kauai, on the banks of a forest stream. This is a rare species, as hitherto it has been "collected only by Knudsen, on the mountains of Waimea, or Halemanu."

September 30 (2856).

Dubautia plantaginea GAUD. Bot. Voy. Uranie. 468, *pl. 84.* 1830.

Hillebrand says this species grows on "Oahu on both mountain ranges, at elevations of near 3,000 feet." I have seen it on Konahuanui, at elevations of 1,500 to 2,500 feet, but never higher. Above 2,500 feet, its place is taken by *D. laxa*. It is much larger in every way than that species, and has a paniculate instead of corymbose inflorescence. The flowers are either yellow or purple. It is a slender tree, often fifteen feet high.

November 2 (2909); original locality, Oahu.

ECLIPTA L. Mant. 2:157. 1771.

Eclipta alba (L.) HASSK. Pl. Rar. Jav. 528. 1848.

Verbesina alba L. Sp. Pl. 902. 1753.

Rather common about Honolulu, in old taro ponds and near streams, but sometimes in dry ground.

March 21 (1979); original locality, "in Virginia, Surinamo."

EMILIA CASS. Bull. Soc. Philom. 68. 1817.

Emilia flammea CASS. Dict. Sc. Nat. **14**: 406. 1819.

An introduced plant, and not recorded by Hillebrand. It is most abundant in Nuuanu valley on the outskirts of Honolulu, and a few plants were found on the edge of the woods along the Tantalus road. A thin leaved, glaucous plant, with scarlet flowers.

May to October (2296).

ERIGERON L. Sp. Pl. 863. 1753.

Erigeron bonariensis L. Sp. Pl. 863. 1753.

Erigeron albidum A. GRAY, Proc. Am. Acad. **5**: 319. 1862.

Hillebrand mentions this species as "gregarious in parts of Molokai and Maui." It is also abundant in pasture land above Waimea, Kauai, at elevations of 1500 to 4000 feet. A simple stemmed, leafy perennial, often six feet high. The leaves are a dull, dark green, coarsely toothed, and the stem hirsute.

September 15 (2819); original locality, "in America australi."

Erigeron canadensis L. Sp. Pl. 863. 1753.

Growing with the preceding, but a more slender and less leafy plant. In dry ground near Honolulu, it is often only two or three inches high. A weed of almost world-wide distribution, and was originally recorded from "Canada, Virginia, nunc in Europae australi."

September 15 (2820).

GNAPHALIUM L. Sp. Pl. 850. 1753.

Gnaphalium purpureum L. Sp. Pl. 854. 1753.

Luxuriant forms, freely branching from the base, are found in cultivated ground near Honolulu. I have collected the same form in fields in North Carolina.

March to June (2002); originally from "Carolina, Virginia, Pennsylvania."

Gnaphalium sandwicensium GAUD. Bot. Voy. Uranie, 464. 1830.

Hillebrand refers this to *G. luteo album* L., and says that it occurs on "all islands, in dry or rocky localities, particularly of the upper region." On Oahu it was collected only a few feet

above sea level, at Diamond Head. The leaves are very white wooly.

March 20 (1957).

LIPOCHAETA DC. Prodr. 5: 610. 1836.

Lipochaeta calycosa A. GRAY, Proc. Am. Acad. 5: 130. 1862.

A suffruticose plant about two feet high, with stiff, almost sessile lanceolate leaves, and yellow flowers almost an inch in diameter. Collected at the original locality, "Diamond Hill, Oahu," where it grows on steep slopes.

March 28 (2021).

Lipochaeta connata (GAUD.) DC. Prodr. 5: 611. 1836.

Verbesina connata GAUD. Bot. Voy. Uranie, 464. 1830.

DeCandolle's description of "suffruticosa, foliis sessilibus connatis rhombeo-ovatis argute et grosse duplicato-serratis supra scabris subtus dense hispidis," can apply only to my No. 2787, collected at the base of the plateau above Waimea, Kauai. The plants are stout, four to five feet high, with harsh, thick, connate leaves, which are somewhat variable in shape, some of them being very long and linear-lanceolate.

August 31 (2787).

Lipochaeta

No. 2563, collected on Kauai near Hanapepe, is one of the numerous plants referred to *L. connata*. It seems to answer fairly well to Gray's *L. australis* var. *decurrens*. The stiff, scabrous, ovate-lanceolate leaves are contracted into a broadly winged petiole, instead of being connate. The plant is woody, erect, about two feet high, and somewhat branched. It grows along the road, on the edge of the precipitous bank of the Hanapepe river, just outside of the town. Apparently the same thing, but with thinner and sharper serrated leaves, was collected in a thicket in Hanapepe valley, some three miles above the first station. Here it is more protected, which would account for the difference in growth. If not specifically distinct from *L. connata*, it is certainly a well marked form.

July to August (2563).

Lipochaeta integrifolia (NUTT.) A. GRAY, Proc. Am. Acad. 5:130. 1862.

Microchaeta integrifolia NUTT. Trans. Am. Phil. Soc. (II) 7:451. 1841.

Hillebrand says "branches not over 1 ft. long." They are really often four feet long. The base is lignescent, and from this spread many prostrate, herbaceous branches, Collected on the old lava flow back of Diamond Head.

April 8 (2092).

RAILLARDIA GAUD. Bot. Voy. Uranie 469, *pl. 83.* 1830.

Raillardia latifolia A. GRAY, Proc. Am. Acad. 5:132. 1862.

In the original description this is said to be "a rambling shrub," and Hillebrand, with his splendid opportunities for exploration of every island of the group, quotes the same expression. It is really a vine. The main stem is often two inches in diameter, and twenty or thirty feet in length. The flowering branches are found running and twining over the branches of trees, one tree near Gay & Robinson's Kaholuamano house, above Waimea, Kauai, having its top completely covered with the vine. The inflorescence is a large panicle, often two feet in length, and is very handsome when covered with the yellow flowers, which bear some resemblance to the flowers of our golden rods. It has been found only on the island of Kauai.

October 15 (2887).

SIGESBECKIA L. Sp. Pl. 900. 1753.

Sigesbeckia orientalis L. Sp. Pl. 900. 1753.

A common weed along Nuuanu avenue, Honolulu, and also in cultivated ground. The Chinese use it in some manner as a remedy for cuts or sores. A pubescent annual, with glands on the slender, club-shaped involucral bracts.

March to October (2036); original locality, "in China, media ad pagos."

VERNONIA SCHREB. Gen. Pl. 2:541. 1791.

Vernonia cinerea (L.) LESS. Linnaea, 4:291. 1829.

Conyza cinerea L. Sp. Pl. Ed. 2, 1208. 1763.

A slender annual, one to two feet high, very different in appearance from the large, coarse American species. The leaves are small, about an inch in length, the lower one obovate, and

the upper ones lanceolate. The flower heads are small, pale purple.

April to October (2175); original locality, "in India."

XANTHIUM L. Sp. Pl. 987. 1753.

Xanthium strumarium L. Sp. Pl. 987. 1753.

A common weed about Honolulu. On Kauai it has become a a great nuisance in pasture land near the coast, as the burs become entangled in the manes and tails of horses. It is found only at low elevations. Collected in lower Pauoa valley, Oahu. It is of wide distribution, originally having been recorded from "Europa, Canada, Virginia, Jamaica, Zelona, Japonia."

CICHORIACEAE.

CREPIS L. Sp. Pl. 805. 1753.

Crepis japonica (L.) BENTH. Fl. Hongkong. 194. 1861.

Prenanthes japonica L. Mant. 1: 107. 1767.

Said to be an introduced species. It is found only in the forests, and appears to be native. On Konahuanui, Oahu, it is found as high as 2500 feet. Usually a slender plant, eight or ten inches high, but sometimes rather stout, branched above, two to three feet high. The thin leaves are lyrate, and the heads numerous, yellow flowered.

April to June (2074); original locality, "in Japonia."

HYPOCHAERIS L. Sp. Pl. 810. 1753.

Hypochaeris radicata L. Sp. Pl. 811. 1753.

A plant not recorded as growing in the Hawaiian group. It is about twenty inches high,with smooth, slender stem, branching above, and destitute of leaves, which are all crowded together as a bunch of prostrate lyrate root leaves. The yellow heads are an inch in diameter. Collected on the plateau above Waimea, Kauai. It grows on the edge of the forest, at 4000 feet elevation, and must have been introduced in some way from Australia, as it grows in that country.

September 30 (2835); original locality, "in Europae cultoris pascuis."

XLIX. THE PHENOMENA OF SYMBIOSIS.

ALBERT SCHNEIDER.

INTRODUCTION.

All living organisms manifest a more or less intimate biological interdependence and relationship. In fact, their very existence depends upon this condition; therefore no organism, no matter how simple or how complex its structure may be, is the result of a wholly independent phylogenetic development. Upon careful study and investigation it is found that, although this interrelation and interdependence vary greatly as to quality and quantity, there may be found innumerable intermediae phenomena which make it difficult to draw the dividing lines. Such a difficulty is, for instance, encountered in attempting to distinguish between mere "associations" or societies (according to Warming and others) and true symbiosis.* Both are evident phenomena of biological interdependence with the general difference that in the former the interdependence is remote, in the latter more close.

Great difficulty is encountered in limiting and defining the biological relationships in the animal kingdom. Highly automobile organisms do not permit the ready establishment of symbiotic relationships as we have come to understand them. Symbiosis presupposes a certain relative fixedness of the organisms. Thus it is that we may find clearly defined symbioses between highly automobile organisms and those which are comparatively non-motile. Here it is very essential to keep distinct the difference between auto-mobility and passive motility (immobility). The former tends to counteract or reduce the occurrence of symbiosis; the latter favors its occurrence as well as its modification, as will be explained later in the discussion. The most clearly defined and most highly specialized forms of symbiosis occur between non-motile organisms.

* The term is used throughout in its broader meaning, not in the sense of De Bary.

Motility or non-motility of organisms has little or no direct influence upon the more remote relationships. From the fact that these latter phenomena are most conveniently limited, geographically, it becomes evident that they are largely dependent upon the influence of the soil, the climate, moisture, etc. (meteorological influences)

The largest and, at the same time, the most remote association of organisms is the hemispherical. The faunal and floral differences between the eastern and western hemispheres are considerable, as every naturalist can testify. That the association is remote is evident from the numerous exotic plants and animals which have become perfectly habilitated. In each hemisphere we again recognize subdivisions of associations, which may be designated as zonal. Here the interdependence is more marked, and is primarily dependent upon the influence of temperature and light. The fauna and flora of the tropics are essentially different from those of the temperate zone, and this again is different from the arctic. Each of the zonal areas is again subdivided into numerous larger or smaller geographically limited societies, dependent upon local influences, as soil, elevation, moisture, etc. For example, life in the Mississippi valley is essentially different from that in the Rocky mountain system. In each area the organisms are specially adapted to each other and their environment. In each of these divisions we find numerous smaller societies. The process of subdividing could be carried on indefinitely. These smaller subdivisions may be natural or artificial, as pond, brooklet, meadow, field, roadside, town, city, etc., each of which has its peculiar fauna and flora.

Within each of these numerous associations, great and small, we find the organisms acting and reacting upon each other. Here there seems to be a mutualistic association of two or more organisms, while the next-door neighbors may be engaged in a struggle with each other for existence. A single example will suffice to illustrate this. The wood-peckers and trees evidently form a mutualistic association, while insects and larvae are diligently hunted by the wood-pecker. Weasel and wood-pecker again are antagonistically related. It is not the purpose of this paper to enter into the details of biological associations and societies. It is hoped that these preliminary suggestions will indicate the close relationship existing be-

tween what is usually designated as mere association of living things and what constitutes true symbiosis. The nearness of these relationships will become still more evident on attempting to define symbiosis.

Definition of symbiosis.—Etymologically the word symbiosis signifies "a living together." It is therefore peculiarly fitted for use in the broader sense, as including all phenomena of "living together." Owing to the mutability and imperfections of a language the etymology of a word is not sufficient to limit its application. A careful definition or explanation is always necessary. Symbiosis may be defined as *a contiguous association of two or more morphologically distinct organisms, not of the same kind, resulting in a loss or acquisition of assimilated food-substances.* This definition is by no means perfect. It will, however, be left to further discussions to point out and explain its deficiency.

The origin of symbiosis.—It is self-evident that before a symbiotic relationship between morphologically distinct organisms could be established it was absolutely necessary that they be brought in close proximity, or in actual contact. It is also clear, from *a priori* reasoning, that there could be no inherent tendency within these organisms to attract or repel each other; nor could the first contact have been co-incident with morphological and physiological adaptations. The very conception of symbiosis implies something secondary, and in a certain sense something abnormal. The establishment of marked symbioses required long periods of time; just when they began is impossible to determine. It is, no doubt, justifiable to assume that a number of lowly organized organisms existed in a natural state, manifesting no symbiotic phenomena, because competition (for space) had not yet resulted from over-productiveness. It may also be assumed that symbiotic phenomena began to manifest themselves during the earliest geologic ages. All the multitudinous phenomena of antagonistic symbiosis, and of mutualistic symbiosis, are highly specialized biological conditions which were initiated by the first contact of morphologically distinct organisms. This contact produced a change in the environment. An unforseen struggle was the result, since it is reasonable to assume that the first relationship of contiguous organisms was antagonistic rather than mutualistic. As already indicated, organisms are not primar-

ily adapted to form symbiotic relationships; therefore the organisms, during their first contact, had the same relation to each other that they had to their substrata, or more correctly to their entire environment. The changes in the substrata are destructive (disintegrative), due to the food-requiring and reproductive life-action of the organism. The antagonism in the incipient symbiosis is, however, so slight as to be incapable of detection. Subsequently antagonism may be increased or be converted into nutricism or mutualism; this depending largely upon the nature of the symbionts. It becomes very evident that the question of the origin of symbiosis is directly concerned with the questions of the "struggle for existence," "survival of the fittest," as well as with the problems of general evolution. We may cite the case of parasitic fungi for the purpose of explaining the probable origin of antagonistic symbiosis. Most fungi are, no doubt, derived from algae, as certain morphological similarities would lead us to believe. Owing to lack of space, or over-productiveness, certain algae frequently came in contact with more highly organized plants and animals from which they absorbed (by osmotic action) various organic food-substances, thereby reducing the necessary activity of chlorophyllian assimilation. Co-incident with the first contact and resultant change in function, there was a corresponding change in structure. As the opportunities for the symbiotic association continued (perhaps more or less interruptedly), the morpho-physiological changes progressed in the direction of parasitism and away from independence. Finally the originally independent chlorophyll-bearing and carbon assimilating organism became wholly dependent upon an organic food-supply and sustained a total loss of the chlorophyllian function. There is no doubt that the host plant or host-plants are also more or less affected by the symbiosis. The relative morpho-physiological changes are approximately in proportion to the size (volume) and biological activity of the organisms.

Above all it is desirable to keep distinct the difference between mere associations and societies of organisms and symbiosis proper. Unless this is done we shall further complicate a subject which is already very complicated The former conditions are of great importance biologically, but the latter attract the most attention at present because of their intimate relationship with the well-being of man himself. There is scarcely a problem of economic significance which is not directly con-

nected with some form of symbiotic relationship of organisms. One needs but call to mind the recent discoveries in the treatment of disease, modern surgery, agriculture, dairy industries, etc. A mere mention of all the experimentation and discoveries in connection with symbiosis would fill volumes. The object of this paper is simply to define the various phenomena of symbiosis according to the present status of our knowledge and to indicate some of the difficulties encountered in the treatment of the subject. Much careful research is yet necessary in order to clear up the uncertainties in regard to the biological significance of many of the symbioses. In order to impress this uncertainty more fully we shall mention a few symbiotic phenomena which are either not recognized as such or improperly classified, usually as parasitism.

UNCLASSIFIED SYMBIOTIC PHENOMENA.

Under this heading will be briefly mentioned numerous and varied phenomena which are of undoubted symbiotic nature, but are not understood or have not been sufficiently studied to give them a definite position in the system of symbioses here proposed. Some of these phenomena are of a very complicated nature and indicate a long phylogenetic development. In many instances the morphological adaptation and relationship of the organisms is so remote as to awaken serious doubt as to its symbiotic nature. Under this category belong the mutual adaptation of plants (entomophilous and other flowers) and animals; also the various forms of mimicry, the association of various species of aphidae and ants upon certain plants, besides many other phenomena. The association of trees, such as the myrmocophilous *Cecropias* and representatives of other genera, with ants, is by many designated as true mutualistic symbiosis. In reality, however, the mutual morphological and functional adaptations are as remote as in some of the instances just cited.

The relation of the male and female reproductive cells is of a truly symbiotic nature. It represents a most specialized individualism. The relationship existing between the immature embryo and the food-supplying parent-stock is evidently a form of symbiosis. There are numerous instances in both the animal and vegatable kingdom in which the more or less imperfect but complete second generation lives in a symbiotic relationship with the first generation. The relationship existing between sporophytic and gametophytic generations can not be

considered as of a symbiotic nature since the two generations are parts of the same ontogeny. There is however no doubt that the two generations form a highly specialized symbiosis (individualism).

There are many other phenomena of a complicated nature which are designated as true parasitism by some authors while others discuss them without referring them to any symbiotic category. Some of these will receive mention in order to indicate more clearly the complexity of the subject.

Several species of crab belonging to the genus *Stenorhynchus* are usually covered by a growth of algae, sponges and other plants and animals. This is perhaps a case of accidental symbiosis. The habitat of the crab combined with its slow movement makes the chitinous skeleton a suitable substratum for the attachment of various aquatic organisms. The covering may serve some protection but this is evidently of no significant importance. Species of the closely related genus *Inachus* are also covered by a similar growth but here the plants and animals serve as food for the crab. Brehm states that the crab even transplants hydroids, algae and other organisms upon its back, thus converting itself into a traveling zoologic and botanic garden. Another crab is totally hidden by sponges growing upon it which enables it to approach its prey unpercieved as well as to hide it from its enemies. Although some of these phenomena seem very complicated, there is no evidence of marked symbiotism. If more than mere accidental symbiotism does exist, no experiments have been made to demonstrate whether it is antagonistic or mutualistic.

The hermit crab is morphologically adapted to live in the empty shells of certain snails. The last pair of legs are much shortened and serve the special function of holding the shell. The coleopter *Necrophilus subterraneous* attacks live snails, eats the animal and then moves into the empty shell. The crayfish *Phronima sedentaria* eats species of *Doliolum* and *Pyrosoma* and utilizes the empty skeleton as a dwelling place, paddling it about by means of its claws. Although these phenomena are in part of a symbiotic nature, yet one must hesitate to place them in this category, since the hunting, killing and eating process is not true parasitism (antagonistic symbiosis). According to definition, symbiosis necessitates a prolonged contiguous relationship. This is not the case with the carnivorous animals and their prey. The apparently wonderful adaptations of the crab and other animals to the snail-shell and

the outer skeletons of animals is perhaps purely accidental unless it can be proven to the contrary that the structural conformations are the result of phylogenetic development.

Climbing plants are interesting as they mark the beginnings of a highly complicated form of symbiosis. The plants form a close association with their supports, which in most cases are living plants; especially is this the case in the dense jungles of the tropics. Whether these plants cling to their support by means of twining stems, tendrils, suctorial organs or aerial roots, there is more or less absorption of soluble food-substances from the living support and in so far it constitutes a symbiotic relationship. The morphological adaptations favoring climbing are however primarily for the purpose of bringing the assimilative tissues nearer the sunlight, and away from excessive moisture. The support is necessary in order to enable them to enter into successful competition with other plants. In many instances the supporting plant plays the part of a host as in true parasitism (*Cuscuta*). There is little doubt that the members of the Dodder family were originally climbing plants which took almost their entire nourishment from the soil and air. The contact with the supporting plants gradually developed a wholly parasitic habit. In many of the climbing plants the supporting function predominates while the symbiotic relationship remains practically zero. This is especially true of the large thick-stemmed climbers of the tropics.

Highly interesting though little understood are the frequently occurring neoformations in animals, such as tumors (lipoma, asteoma, sarcoma, carcinoma, etc.,) and cysts of various kinds. Although the origin and true nature of the structures is not well understood, yet they shall receive mention here since they partake of the nature of symbionts. It is generally believed that these growths are neoformations arising from the development of dormant embryonic cells. They are foreign to the body in which they live as true parasites, greatly sapping vitality or even destroying life. Various theories have been advanced as to the nature of these growths but none have thus far proven tenable. It is however hoped that the investigations of the near future will give more satisfactory results.

In conclusion we shall mention a few symbioid phenomena from the insect world and show how they are gradually converted into undoubted symbioses. Different species of wasps

narcotize or paralyze spiders, crickets or caterpillars by stinging, thus rendering them motionless. In this condition they are sealed into the wasp's nest containing the egg, in order to serve as food for the young wasp. This condition becomes more complicated by the intrusion of another wasp which unobserved lays its egg in the nest already supplied with the necessary food. The foreign egg develops first and the young wasp not only eats the food supplied by its foster mother, but also the egg. From these conditions to true parasitism is only a step. Some wasps lay their eggs directly into the tissues of the caterpillar. The egg develops and the young larva feeds upon the less vital tissues of the host so as to prolong life as much as possible. Finally only the outer tegument of the host remains which is utilized as a protective covering during the resting stage.

We may also mention the phenomena induced by grafting. These are usually not designated as symbioses though they evidently partake of that nature. It is true graft and stock do not form an association of two *complete* individuals, yet in their functional relationships they form a most perfect symbiosis (mutualism).

These examples will suffice to make clear how difficult it is in many instances to recognize phenomena of undoubted symbiosis.

RECOGNIZED PHENOMENA OF SYMBIOSIS.

The phenomena of symbiosis here defined have been more or less discussed by scientists and have received recognition. Authors are, however, at variance as to their exact limitations which makes the definitions subjectively variable. The phenomena of symbiosis may be classified as follows:

I. Incipient Symbiosis (Indifferent Symbiosis).
   1. Accidental Symbiosis.
   2. Contingent Symbiosis (*Raumparasitismus*).

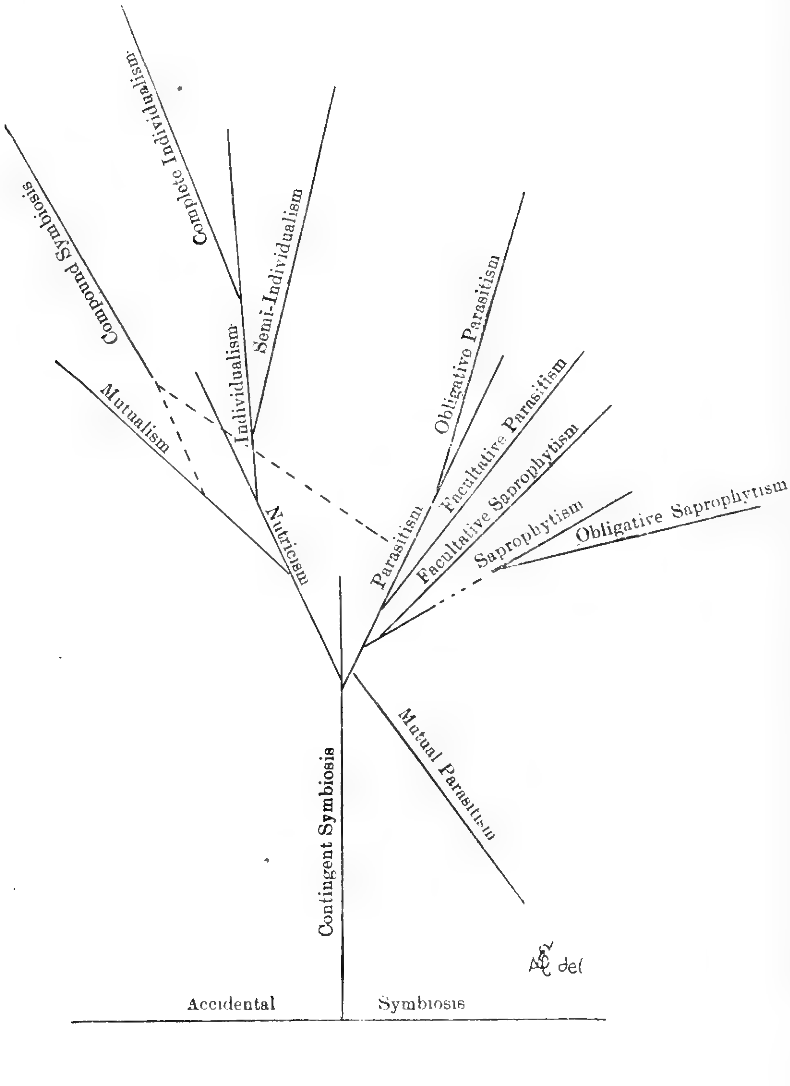
II. Antagonistic Symbiosis.
   1. Mutual Antagonistic Symbiosis (Mutual Parasitism).
   2. Antagonistic Symbiosis (Parasitism).
      a. Obligative Antagonistic Symbiosis.
      b. Facultative Antagonistic Symbiosis.
   3. Saprophytism.
      a. Facultative Saprophytism.
      b. Obligative Saprophytism.

III. Mutualistic Symbiosis.
   1. Nutricism (Semi-mutualistic Symbiosis).
   2. Mutualism.
   3. Individualism.
      a. Semi-individualism.
      b. Complete Individualism.

IV. Compound Symbiosis.

These phenomena are represented by the association of widely different organisms. Organisms similar to those which enter into an antagonistic symbiosis will occur in mutualistic symbiosis. This seems to indicate that the development of these associations depends largely upon opportunity (environment). To some extent, however, the organisms control or modify the symbiotic relationship as indicated in the introduction. A classification of the phenomena indicating their phylogenetic relationship can therefore not be based upon the organisms which enter into their formation. One can only indicate the physiological relationship of the phenomena and their approximate relative evolution.

The accompanying figure and the brief discussions of the phenomena will doubtless suffice to make clear their relationships and limitations. The figure is intended to indicate the phylogenetic relationship of the symbioses without any reference to the phylogeny of the organisms comprising them. Accidental symbiosis is indicated as forming the basis from which the other forms developed. Parasitism should, perhaps, have been indicated as taking its origin below nutricism. Saprophytism proper is not symbiosis. It is introduced in the figure to show its probable relationship to the symbiosis. The only compound symbiosis indicated is that of mutualism with parasitism. Further investigations may reveal others.



Complete Individualism
Compound Symbiosis
Semi-Individualism
Individualism
Mutualism
Obligative Parasitism
Facultative Parasitism
Facultative Saprophytism
Saprophytism
Obligative Saprophytism
Parasitism
Nutricism
Mutual Parasitism
Contingent Symbiosis
Accidental
Symbiosis

I. *Incipient Symbiosis* (*Indifferent Symbiosis*).

Under incipient symbiosis are included the multitudinous phenomena of symbiotic relationships, which have not yet acquired evident antagonistic or mutualistic characters. In many instances there are marked morphological adaptations, but without any *apparent* corresponding functional activity. In far the greater number of cases there is simple contact resulting from over production. In view of this fact one may be criticised for recognizing such relationships as symbioses. From *a priori* reasoning one is, however, forced to conclude that the first symbiotic activities began with the first contact of organisms. Incipient symbiosis, therefore, forms the basis or common source of all symbiotic phenomena. From it gradually emerged highly complicated morphological and physiological adaptations of originally distinct organisms. There is also little doubt as our methods of investigation become more highly perfected many of the symbiotic phenomena now considered as indifferent will be relegated to the realms of antagonistic or mutualistic symbiosis.

1. **Accidental Symbiosis.**—This represents the least specialized form of symbiosis, but is of wider occurrence than all the others combined Accidental symbiosis is represented by the mere coming in contact of two or more morphologically distinct organisms; such contact being, however, sufficiently prolonged to give it the semblance of a symbiosis. Mere momentary contact is not symbiosis as here understood.

Accidental symbioses are particularly numerous where there is luxuriant growth, hence where competition is great, as in the tropics and in green-houses. The lower parts of plants in green-houses are covered with bacteria, hyphal fungi, algae and more rarely some of the lower protozoa. The epidermal cells of many plants contain more or less bacteria. Submerged plants are covered with mollusks, hydras, tubullarians, amoebas, vorticellas, etc. The larger land and water organisms furnish hiding places and protection for hosts of smaller organisms. In fact, no organism is free from the accidental association with other organisms, omitting of course in all cases the coterie of recognized parasites.

In all the instances mentioned there is no perceptible evidence of either antagonism or mutualism. Injurious results may occur, but they are due to mechanical causes. Slight morphological changes usually result, but such changes seem

to have no effect upon the life-history and development of the symbionts.

There is no doubt that accidental symbioses forms the basis whence gradually emerged all other forms of symbiosis. Perhaps few symbiotic associations were from the very first markedly antagonistic, and still less rarely markedly mutualistic for reasons already stated.

To the category of accidental symbiosis also belong the association of climbing plants and their living supports. The symbiotic relationship was at first merely accidental resulting from the contact. It is a striking example illustrating how marked and highly specialized morphological adaptations favoring one function may initiate widely different morpho-physiological changes. In the case of climbing plants it is impossible to know when the symbiotic relationship begins to overbalance the function of mechanical support. It is just as difficult to determine when marked symbiotic phenomena begin to manifest themselves. It is safe to conclude, however, that the morphological changes favoring climbing and support progressed considerably before any marked symbiotic relationships occurred.

It is also evident that accidental symbiosis is a condition readily subject to change, since the permanency of symbioses is in direct proportion to the degree of mutualistic specialization. Each plant and animal may enter into accidental symbiotism with other plants and animals. In a given animal this association changes with a change of locality, in temperature, or of moisture; in fact, with every change in the environment. The absence of all permanency in morphological and functional relationship characterizes accidental symbiosis. It resembles a form of haphazard experimentation on the part of nature to determine whether or not a definite symbiotic relationship can be established.

2. **Contingent Symbiosis.**—In this form of symbiosis the relationship of the organisms is already sufficiently marked to give the semblance of an elective affinity, although the functional interdependence is as yet not manifest. It is of wide occurrence among widely different organisms. Many phenomena heretofore recognized or variously classified as parasitism, perhaps belong to this category. Most of the phenomena recognized by the German scientists as *Raumparasitismus* also belong here. The citation of a few examples will suffice to explain the nature of contingent symbiosis, and to distinguish it

from mere accidental symbiosis as well as from the more highly specialized forms of symbiosis.

There is a difference between the bacterial flora of the digestive tract of man and that of the chicken or dog. Certain bacteria, which have not yet become markedly antagonistic or mutualistic in their symbiotic associations, show a preference for one digestive tract which indicates that there must be some elective affinity. That the elective affinity is only slight is evident from the fact that the bacteria referred to will very readily grow and multiply upon artificial culture media, and may readily be induced to change hosts. Some algae show an elective affinity for certain living substrata. *Sirosiphon pulvinatus* occurs quite constantly upon species of *Umbilicaria* and *Gyrophora*. *Pleurococcus punctiformis* occurs upon the young thallus of *Cladonia* and *Baeomyces*, *Pleurococcus vulgaris*, on the other hand, occurs upon the most varied substrata living and dead; hence this association is evidently only accidental, as the alga shows no preference for any particular host. It has, perhaps, a slight preference for some of the *Polyporei*.

Some of the higher crustaceans select certain corals, among which they live, without forming any marked symbiotic relationship. In one locality (geographical area) *Hydra viridis* seems to prefer one vegetable substratum (*Nuphar*), while in another locality it prefers to live upon another plant, *Lemna polyrhiza*. Some Rotifera show a preference for certain plants to which they attach themselves. Certain algae, as species of *Dactylococcus* and *Euglena*, show a decided tendency to locate upon such animals as Cyclops, snails and clams. Some mammals (sloth, ant-eater, and others), have algae living upon them. The symbiosis of snails with corals is perhaps contingent. Some sponges and hydroids show a preference for animals, others for plants. Marine life in particular presents many forms of contingent symbioses. The instances cited are sufficient to indicate the nature of contingent symbiosis Many require further careful study before anything definite can be stated as to their biological activity and relationship to other symbioses.

II. *Antagonistic Symbiosis.*

The phenomena included under this head are of wide occurrence and were the first to receive the attention of scientists. The term as here used includes mutual antagonistic symbiosis and antagonistic symbiosis proper. The former is not gener-

ally recognized by authors. The latter is more commonly known as parasitism. There are no objections to the use of the term parasitism, since it has become clearly defined and definitely restricted in its application. It is, however, recommended that the term antagonistic symbiosis be substituted for the sake of uniformity in terminology.

From the nature of things the morpho-physiological specializations and adaptations of antagonistic symbiosis are limited. Although one of the symbionts may be highly benefitted the other is always injuriously affected. This injurious effect may finally reach the stage where it will react upon the parasite, thus indirectly resulting in the mutual destruction of the symbionts. In far the greater number of instances the host is not destroyed, nor even seriously injured, although its morphological changes tend in that direction; a condition which will of necessity react upon the parasite. From this it also becomes evident that it is desirable for the parasite to locate upon a host whose vitality and biological activities are many times greater than its own. This we find to be the case, the host is quite generally a large plant, while its parasites are comparatively small.

Strictly speaking, antagonistic symbiosis is therefore a destructive association. The morphological and physiological changes tend toward dissolution rather than evolution. It is a change from the higher to the lower, hence a katabolic change. There is, however, no doubt that symbioses which were originally antagonistic may be subsequently converted into mutualistic symbiosis. Reinke expresses the opinion that the lichen prototype was the result of the parasitic association of a fungus and an alga (*Nostoc*). This transition from antagonism to mutualism, however, takes place early in the phylogeny of the symbiosis.

As has already been indicated, the majority of symbioses were perhaps originally more or less antagonistic, although actual experiments are wanting to prove this. Incipient antagonistic symbioses are, however, in existence, represented by some Chlorophyceae and Cyanophyceae, in and upon higher plants. In time these algae will no doubt lose their chlorophyllian function and depend entirely upon the organic food supply of the host. The yeast-plant was no doubt originally a green alga. Whether the majority of the bacteria are also derived from algae is still is dispute.

1. **Mutual Antagonistic Symbiosis (Mutual Parasitism).**—Mutual parasitism as such has heretofore received little or no recognition. It is a phenomenon characterized by the mutual antagonism of the symbionts and is therefore essentially different from antagonistic symbiosis proper or parasitism. It is a relationship which can not readily occur. If, for example, two or more symbiants nearly equal in size and in vitality, enter into a relationship of mutual antagonism two things may occur. Owing to the antagonism a prolonged symbiosis is impossible, and the symbionts will adhere to the original substrata or they will mutually destroy each other. It is, however, highly probable that an association of organisms, which was at first more or less mutually antagonistic, later developed into antagonistic symbiosis proper or even into mutualistic symbiosis.

Complete and simultaneous mutual antagonism of the symbionts is certainly of rare occurrence. Further careful study may reveal phenomena of this nature. Various forms of mutual antagonism do, however, occur. It exists, for example, between normal cells of plants and animals and certain disease-producing germs (bacteria, etc.) The ability of the cells to resist the attacks of certain germs is spoken of as "physiological resistance" or "natural resistance." In fact, the recent investigations and discoveries in regard to immunity, toxine and anti-toxine, are based upon this mutual antagonism between host and parasite. This antagonism varies greatly between different organisms. Phagocytosis is another example of mutual antagonism. Under ordinary circumstances the phagocytes destroy all of the germs with which they came in contact, thus preventlng the occurrence of diseases or other disturbances. Under certain conditions the germs, however, gain the upper hand and destroy the phagocytes. It must be admitted that the subject is as yet not well understood.

The above are the most typical examples of mutual antagonistic symbiosis and their brief mention will suffice to indicate the true nature of this phenomenon.

2. **Antagonistic Symbiosis (Parasitism).** — Antagonistic symbiosis in some of its forms is familiar to all, and for that reason it will not be necessary to dwell upon its nature. We shall, however, briefly mention some of the important relationships of host and parasite, and refer to some of the less-known forms of parasitism.

In many instances the host is destroyed without any preliminary morphological changes. The parasite simply enters the cells and destroys them by assimilating the plasmic contents. This form of symbiosis Tubeuf designates as *Perniciasm.* In other instances, also belonging to perniciasm, there are slight secondary changes before death takes place; resulting in rudimentary galls or mere swellings.

In other instances death is the result of ferments and ptomaines generated by the parasite, as in various diseases of animals as well as of plants Some parasites dissolve the cell-wells of the host, while others simply lie in contact with the cells and absorb the contents by osmotic action. In a great number of instances hypertrophies and abnormalities in growth are induced (galls, hypertrophied fruits and leaves; enlargements in animal tissues). Again, atrophy, or a total check in development, may occur as the result of parasitism.

With some parasites the host adaptation has become highly specialized. In the phenomena known as heteroecism the successive generations of the parasite develop upon different host-plants. For example, *Puccinia graminis* develops its aecidiospores upon *Berberis vulgaris,* while its teleutospores are developed upon some of the grasses, as wheat or oats. Most parasites do, however, not have successive autogenetic generations. Many are limited to one host-species, or even to definite tissues or organs.

One organism may enter into different forms of symbiosis. For example, the bacillus of typhoid fever may enter into an accidental (perhaps contingent) symbiosis with the oyster, while with man it forms an antagonistic symbiosis. The bacillus of Asiatic cholera, likewise, may live in and upon various animals without any injurious effects, but as soon as it finds its way to the intestinal canal of man it acts as a true parasite. The distinction into facultative and obligative parasitism depends upon the ability that some organisms have of living as parasites and saprophytes, while others are alsolutely dependent for their existence upon association with the host.

The most common parasites are the fungi. The Schizomycetes form antagonistic symbioses, preferably with animals. The higher fungi predominate upon vegetable tissue. Many diseases of animals are also due to the higher fungi. Algae occur parasitically in and upon plants and animals. Many of the Chlorophyceae and Cyanophyceae occur as parasites upon higher plants. Many of the marine algae are parasitic upon

each other as well as upon marine animals. Higher plants are often parasitic (Mistletoe, Dodder, Indian Pipe, etc.) Protozoa occur parasitically upon animals. An amoeba-like organism is said to cause malaria. Different varieties causing different forms of malaria have been described. Higher animals occur in and upon animals and plants, producing manifold injurious effects. The instances of parasitism are, in fact, too numerous to mention.

Most interesting is the phenomenon of sex-parasitism in which one sex, usually the male, lives parasitically upon the other. In one of the parasitic crustaceans the male is entirely dependent upon the female for its sustenance. Among the *Bouellias* the male is represented by a mere fertilizing structure parasitic within the reproductive organs of the female.

In conclusion, we will mention the parasitic relationship of embryos and the mother-organisms. This has already been referred as a questionable form of symbiosis. Klebs is, however, of the opinion that it is true parasitism. The embryo of a plant derives all its nourishment from its parent, and in addition takes from it certain materials which it stores for future use (cotyledons, endosperm). Even after birth the young of many animals remain in parasitic association with the parent. Of the numerous eggs in the black salamander only one develops a young animal, which eats the remaining eggs.

3. **Saprophytism.**—Saprophytism is not symbiosis and will be dismissed with a few words. This is a condition which in many instances was no doubt phylogenetically derived from parasitism as we have all gradations between obligative parasites and obligative saprophytes. In some instances saprophytism no doubt originated as such. Dead organic matter occurs plentifully everywhere and forms a suitable substratum for a number of animal as well as vegetable organisms, having special morpho-physiological adaptations for utilizing such a food supply. This preference was no doubt gradually acquired.

Facultative parasites and saprophytes may of course occur as parasites and in so far belong to antagonistic symbiosis.

III. *Mutualistic Symbiosis.*

This form of symbiosis differs from the preceeding in that the relationship of the organisms is mutually beneficial. Each symbiont possesses or has developed a specific character which is useful for the other symbionts. As in the preceding forms of symbioses widely different organisms may enter into its formation. The morphological changes accompanying the functional relationships may be very marked or scarcely perceptible, nor is the adaptation quantitatively and qualitatively equal for all the symbionts. The adaptation is rather complementary, one organism supplies a deficiency (morphological or physiological) of the others. Theoretically there is no limit to the degree of specialization and perfection that this form of symbiosis may attain. In fact mutualistic symbiosis implies that there is a higher specialization and greater fitness to enter into the struggle for existence. This is most beautifully illustrated in the case of lichens. These plants are of wider distribution and possess greater vitality and physiological activity than either of the symbionts. They occur in the tropics as well as in the extreme north; in the lowest valleys as well as on the highest mountain peaks. Bonnier has shown that their vitality is greater than that of any other plants. Likewise the mutualistic symbiosis occurring in the Leguminosae adapts these almost equally well to rich and poor soil thus giving them a great advantage over other plants. Our knowledge of the higher forms of mutualistic symbiosis is as yet too problematic to permit us to make any authentic statements as to the benefits derived therefrom.

1. **Nutricism.**—Nutricism establishes a connecting link between the lesser marked symbioses and mutualism. It may be defined as a form of symbiosis in which one symbiont nourishes the second symbiont without receiving any benefit in return. It might therefore be designated as one sided or incomplete mutualism. Absolute nutricism, as above defined, does perhaps not occur, for, as already indicated, it is not reasonable to assume that any symbiotic relationship exists in which all of the symbionts are not more or less mutually affected. There are, however, a few instances in which one symbiont is very materially benefitted, while the other is not materially benefitted. The most marked example is met with in the mycorhiza of the Cupuliferae. A mycorhiza is the association of a hyphal fungus with the younger rootlets. The function of

the fungus, which forms a network about the rootlet, is to supply the tree with food-substances and moisture taken from the soil. It also supplants the function of the hair-cells which are wanting in the mycorhiza. It has been proved, experimentally, that the tree is greatly benefitted, while no evidence could be found to indicate that the fungus is benefitted. The hyphae always remain on the outside of the root, and therefore form ectotrophic mycorhiza. The endotrophic mycorhiza of orchids have not yet been sufficiently studied to determine their exact nature. Tubeuf designates it as nutricism.

In *Cycas revoluta* we find a form of symbiosis which is evidently nutricism. It is found that in the majority of cultivated cycads there are numerous tubercular outgrowths from the roots, which usually contain a species of *Nostoc* between the cells of a specialized parenchyma. This is evidently not a form of parasitism as is shown by the fact that the cycads bearing the greater number of tubercles are in no wise injuriously affected; neither has it been proven that the host is benefitted. There is, however, no doubt that the *Nostoc* is dependent upon the host for its food-supply. It may therefore be looked upon as a case of nutricism, in which the host acts as the transfer agent.

Klebs cites an interesting example which is, no doubt, nutri. cism. The crayfish *Pagurus Prideauxii* is constantly associated with one of the actinias (*Adamsia palliata*). The latter is said to be absolutely dependent upon the former for its food-supply. The crayfish receives only a slight benefit if any.

Many other forms of nutricism may come to light when the phenomena of symbiosis are more carefully investigated.

2. **Mutualism.**—This form of symbiosis has been recently discovered. Reinke and de Bary among botanists and van Beneden and Klebs among zoologists were among the first writers on the subject. By mutualism is meant a form of symbiosis in which the symbionts mutually benefit each other but are still capable of leading an *independent existence.* It is an association of wide occurrence and in many instances reaches a high degree of morphological and physiological specialization.

The most striking example occurs in the root-tubercles of the Leguminosae. The tubercles are neoformations induced by the rhizobia which grow and multiply in the parenchyma-cells. The rhizobia take their food supply direct from the plasmic and other cell contents of the host; in return the latter

receives the nitrogenous compounds formed by the bacteria in the process of binding the free nitrogen of the air. It has been proven experimentally that the symbionts may exist independently but thrive much better when in association, especially in poor soil.

To this category also belong the association of ants and trees in the tropics, which has already been referred to. A given species of ant lives upon and obtains its food supply from the branches of a tree (*Cecropia*); in return the ants protect the tree against the attacks of another species of ants. The ants live within the transversely divided hollow stem to which they gain access by eating away the thin lateral (outer) area. The thin outer membrane of which there is one to each hollow chamber and the chambers themselves are, however, perhaps not the result of the symbiotic association. The preexisting morphological characters simply happen to form the establishment of the symbiosis.

In the insectivorous plants (*Drosera*, *Dionaea*, *Nepenthes*) we doubtless have another example of mutualism. Formerly it was generally believed that the plant itself digested the insect which it caught, by the aid of irritable glandular hairs or other special organs. According to recent experiments it is highly probable that the insect digesting ferment is secreted by bacteria which live upon the plant.

A most remarkable instance of mutuamlis occurs in the animal kingdom. The very inactive polyp *Actinia prehensa* lives firmly attached to the inner sides of the claws of the crustacean *Melia tessellata*. The *Actinia* aids in killing the prey of the crayfish while the latter carries its guest from place to place thus giving it better opportunities for securing a sufficient food-supply. Möbius states that this association occurs with all the representatives of *Melia tessellata* both male and female and that it is almost impossible to separate the symbionts without injuring them.

Many of the symbiotic associations of algae with animals are perhaps mutualistic. Many *Actinias* contain single-celled algae which manufacture food-substances for the use of the polyp. Brandt states that as long as this animal contains no algae, it feeds upon the organic substances in the immediate vicinity, but as soon as it becomes associated with the algae it depends upon these for the supply of organic food-substances. Further reseach is necessary to determine whether or not this is really mutualism.

3. **Individualism.**—This form of symbiosis differs from mutualism in that *one* or *more* of the symbionts is absolutely dependent upon the other for its existence. It therefore represents a higher form of mutualism, from which it is no doubt phylogenetically derived. Individualism may be divided into semi-individualism and complete individualism. In the former at least *one* of the symbionts is incapable of existing independently; in the latter *none* of the symbionts can exist independently. The associations form an individual, a morphological unit, and the phenomena are frequently not recognized as symbiosis. Much of our knowledge in regard to individualism is as yet purely hypothetical and theoretical. The subject therefore requires further careful study.

(*a.*) *Semi-individualism.*—This is perhaps of wide occurrence. It is represented by the lower lichens in which the algal symbiont is capable of leading an independent existence, while the fungus can not. In the lowest crustaceous lichens there is perhaps mere mutualism, since several investigators state that the symbionts may live independently as fungus and alga. Another instance occurs perhaps in those leguminous root-tubercles formed by *Rhizobium mutabile.* At least there are no authentic records to prove that this bacterium can grow and multiply in artificial media. Some algae seem to form semi-individualism with animals. According to Kühn, *Pleurococcus brachypodis* and *Pleurococcus chlopodis* occur only upon the body (among the hair) of the two and three-toed sloths. Simple-celled, chlorophyll-bearing algae or chlorophyll-bodies have been found in representatives of the following genera of the animal kingdom: *Amoeba, Dactylospora, Difflugia, Hyalosphaenia, Heleopera, Arcella, Cochliopodium, Actinosphaerium, Rhaphidiophrys, Acanthocystis, Heterophrys, Chondropus, Sphaerastrum, Ciliophrys, Vorticella, Epistylis, Ophrydium, Vaginicola, Euplotes, Urostyla, Uroleptus, Stichotricha, Spirostomum, Blepharisma, Climacostomum, Stentor, Cyrtostomum, Microthorax, Paramecium, Loxodes, Coleps, Lionotus, Amphileptus, Lacrymaria, Phyalina, Holophrya, Enchelyodon, Enchelys, Spongilla, Hydra, Vortex, Mesostomum, Hypostomum, Derostomum, Couroluta, Anthea, Bouellia, Idotea.* In many instances the green particles occurring within the animals are simply remnants of chlorophyll from the algae upon which the animal feeds. In other instances there is an undoubted symbiotic association of the alga and animal.

(*b.*) *Complete Individualism.*—The best known and perhaps the most typical form of complete individualism is represented by the higher lichens. Most authors are agreed that the fungal symbiont has entirely lost the power of independent existence, while the alga may exist independently. Some recent experiments would, however, lead me to believe that the algae likewise have lost the power of continued independent existence. Lichens would therefore form complete individualism. The association of the algae with *Hydra viridis* perhaps belongs to this category. The phagocytes are as yet not sufficiently understood. They, in all probability, establish a complete individualism in association with the animal body, although no experiments have as yet been made to substantiate this. Nor are the phagocytes generally considered as "organisms."

Future experiments may demonstrate that the cell, and hence the individual, is neither more nor less than complete individualism. The plasmic bodies, as chlorophyll granules, leucoplastids, chromoplastids, chromosomes, centrosomes, nucleoli, etc., are perhaps simply the symbionts comparable to those in the less highly specialized symbioses. Reinke expresses the opinion that it is not wholly unreasonable to suppose that some skilled scientist of the future may succeed in cultivating chlorophyll-bodies in artificial media.

IV. *Compound Symbiosis.*

This is the occurrence of two different symbioses upon the same host and is by no means uncommon. It is usually the association of mutualism with parasitism. That is two or more organisms form a mutualistic symbiosis and enter into an antagonistic symbiosis with a third organism. Hueppe mentions an instance in which two different species of bacteria unite before they can locate as parasites upon their common host. In *Manostomum bijugum*, a parasitic worm found in birds, it is known that two individuals always occur together. The instance of sex-symbiosis, already mentioned, perhaps also belongs here. Compound antagonistic symbiosis, which is quite common, is not included here.

In conclusion, it may be stated that this communication simply represents an attempt to systematize the phenomena of symbiosis, thus forming an aid to their future study.

APPENDIX.

Titles of literature concerning the fixation of free nitrogen of plants and symbiosis in general.

The titles here given are a continuation to those given by MacDougal (MINNESOTA BOTANICAL STUDIES. Bulletin No. 9, part IV. 186–221. 1894). It is intended to issue further lists of titles from time to time.

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L. OBSERVATIONS ON THE DISTRIBUTION OF PLANTS ALONG SHORE AT LAKE OF THE WOODS.

CONWAY MACMILLAN.

INTRODUCTION.

During the summer of 1894 the writer in company with Mr. E. P. Sheldon, visited Lake of the Woods, and made an extensive collection principally upon the American islands. This collection covered, as far as was possible, all the groups of plants established in the region. In 1896 with Mr. E. E. Nicholson a second trip was made to the same localities and to several new, for the purpose of securing a series of photographs that might best illustrate the many peculiarities of plant distribution which had attracted attention upon the previous journey. On this occasion, too, a considerable collection was gathered, particularly of mosses and lichens. Professor Bruce Fink has already recorded[1] his determinations of the lichens and Professor J. M. Holzinger is at present engaged upon the identification and distributional study of the mosses. The general collection of ferns and flowering plants made in 1894 will be listed later, either separately or, if this seems undesirable, in a comprehensive paper upon the distribution of plants in Northern Minnesota. It is the purpose of this essay to present without distracting detail those conclusions which have been reached regarding the ecological distribution of plants along the shores of the lake.

To interpret scientifically the location of plant individuals and plant communities is by no means a simple problem. One must recognize, however, that there is always a sufficient reason for the establishment of a given plant upon a given spot and *pari passu* of special plant societies over particular areas of the earth's crust rather than elsewhere. Chance in its

1 **Fink**: Lichens of Lake of the Woods. Minn. Bot. Stud. **1**:693. 1896.

crude form by no means enters into the matter and a sufficiently careful examination of all the manifold environmental, individual and historical conditions should, if the data were at hand, suffice to lay at least the foundations for rational ideas of plant distribution over limited areas. It becomes possible, therefore, to connect directly plant distribution and the aspect of plant formations on the one hand, with atmospheric, geologic, topographic and biologic conditions of the environment on the other. Every landscape thus becomes a definite scientific proposition for analysis and explanation by enlightened observation and judgment.

That branch of biology which concerns itself with the adaptations of organisms to their surroundings is, by the modern school, termed *ecology*, this name having first been applied by Haeckel. Until but recently many writers especially in Germany, have employed, somewhat erroneously the term *biology* with a restricted significance, meaning to cover by it what is now included under ecology. But this need produce no confusion. The science of ecology is capable of extended sub-classification and very definite fields may be delimited within the general boundaries. Just as biology is broadly subdivided into botany and zoology, so ecology naturally presents itself as plant-ecology and animal-ecology. Each of these divisions, pursuing the system followed when the field of botany or zoology is to be further classified, may be refined according to the exact range of inquiry that is proposed. Thus *paleoecology* might be defined as the science of adaptations of fossil organisms—in so far as such adaptations might be brought in evidence,—or *economic ecology*, treating of adaptations in their relation to human interests, might be defined. Four main divisions of the subject are not difficult to indicate. These are as follows:

1. **Ecological morphology.**—This is that branch of biological science which has for its content the adaptational stuctures of organisms Environmental influences as displayed in the architectural reactions of the body come within its scope.

2. **Ecological physiology.**—This must be defined as that branch of biological science which treats of the adaptations of bodily or organic functions to outward forces. Modifications in function, and the laws of their origin and development, under stimulus from without are the field of special study.

3. **Ecological embryology.**—This is that department of ecology which concerns itself with adaptational phenomena in the development of individuals from the germ. Here the modern methods of experimental embryology come into play, and the reactions of the developing egg to its surroundings furnish the phenomena of critical interest.

4. **Ecological distribution.**—This should be defined as the science which treats of the reciprocal relations between physiographic conditions and life requirements of organisms, in so far as such relations manifest themselves in choice of habitats and method of establishment upon them. The structural adaptations that arise when organisms accommodate themselves to particular atmospheric, topographic, climatic, geological, soil chemical or cosmic (including here influences of light as modified by latitude) conditions may properly be regarded as within the domain of ecological morphology or physiology; but the habitats with the resultant origin and development of plant-formations present a line of scientific inquiry distinct enough and worthy of special attention. The essay in hand lies quite within the field of ecological distribution as thus restricted and the discussion of ecological morphological details will not be entered upon.

Physical features of the region.

Geographical position.—Lake of the Woods is situated between latitudes 49° 11′ and 49° 53′ N and longitudes 94° and 95° 35′ W. It lies between the Canadian provinces of Ontario and Manitoba and the state of Minnesota. From north to south and from east to west it extends about sixty miles, and its total area is not far from 1500 square miles. The greater portion of this lies within Ontario, but parts of Muskeg bay and Buffalo bay belong to Manitoba, while considerably more than one-half of the Grand Traverse is within the borders of Minnesota. The international boundary between Canada and the United States runs diagonally across the Grand Traverse, entering the lake at the mouth of Rainy river, and trending northwesterly to the inlet known as Northwest Angle inlet. Here the direction of the line changes abruptly and it runs due south to the 49th parallel, thence due west along this parallel. The intersection of the north and south line with the 49th parallel lies in the Grand Traverse, and the eccentric course of the boundary isolates a portion of land belonging to Minnesota, known to carto-

graphers as the Northwest Angle. Within American waters are about forty islands, of which the three largest are, in their order, Oak, Garden and Flag island.

Drainage.—The drainage basin of Lake of the Woods is approximately 36,000 square miles in extent. This is pretty equally divided between Minnesota and Ontario, only an insignificant fraction belonging to Manitoba. The basin comprises the country along the Rainy river and its tributaries, with the region bordering upon Rainy lake and its sources. The waters of Lake of the Woods empty into the Winnipeg river over two falls, with rapids between the towns of Rat Portage and Keewatin, on the Canadian Pacific railway. These towns are situated upon the extreme northern bay of the lake and the falls, divided by Tunnel island, are now being utilized to develop electric power for transmission to a distance.

General topography.—The mean level above the sea of Lake of the Woods is 1062 feet. Considerable variation—as much as ten feet in some of the bays—between high and low water has been recorded; but such fluctuations are not common, although a variation of from six to eight feet in level is altogether ordinary. The remarkable shape of the lake, as may be seen by reference to the accompanying map, gives the wind an unusual opportunity to raise the level on lee shores when it has been blowing continuously for some hours in one direction. A very great variation by seasons also characterizes the volume of the Rainy river.

As may be noted by further examination of the map, the Lake of the Woods proper separates into two regions, the northern and northeastern island crowded area, sometimes named Clearwater lake on the maps, and the southern and southwestern open, island free area. This latter is called the *Traverse* by local navigators. The smaller lake, tributary by a short series of rapids to Lake of the Woods, and indicated on the map as Shoal lake, has a somewhat similar massing of islands in the northern portion. The eastern bays of the lake are choked with islands, and they are not absent from the western bays in the northern part, but only a few islands close to shore can be seen in Buffalo or in Muskeg bay to the southwest. The shores of the lake are, for the greater part, low, but some altitudes of 100 feet have been observed. Precipitous cliffs, such as those of some of the international boundary lakes between Rainy lake and Lake Superior, are unusual. Here

and there, however, as at Crow Rock island, such cliffs are conspicuous features. Other cliffs of this kind may be seen in Whitefish bay and in Shoal lake. The ordinary shore line is low and rounded. The islands I have previously classified[2] as 1, Bog islands; 2, Sand dunes; 3, Drift covered islands; 4, Dome-shaped rock islands; 5, Irregular or jagged rock islands. The fourth and fifth classes are by far the most abundant.

An intelligent notion of the region is conveyed by Lawson when he terms it a flooded area of *roches moutoneés*. Evidences of profound glaciation are abundant, and the innumerable small islands, which are so characteristic a feature of the scenery, remind one of typical *roches moutoneés*.

The lake is nowhere extraordinarily deep, soundings of 85 feet in the northern portion and 40 feet in the Traverse being exceptional. Where the lake is shallower—that is in the southern part—there is a greater amount of drift upon the bottom. Thus soundings off Garden island in the Grand Traverse always showed a bottom of blueish clay, while to the north the plummet frequently indicated rock, or organic silt, derived from the planktonic flora and fauna.

Origin of the lake.—The bed of Lake of the Woods has undergone extensive preglacial erosion, but the glacial and postglacial history of the region is of particular interest in this connection. Lake of the Woods, together with Rainy lake, Red lake, Lake Winnipeg, Lake Manitoba and Lake Winnepegosis lie quite within the bed of a temporary glacial lake known to students of geology as Lake Agassiz[3]. This lake, for about 1000 years, covered the Red river valley and portions of the valleys of the Saskatchewan and Assiniboine rivers of Canada. It covered, too, the drainage-basin of Lake Winnipeg, and comprised in all about 110,000 square miles. Rainy lake, tributary to Lake of the Woods, lies just within the southeastern boundaries of the ancient lake. At first Lake Agazziz emptied into the Mississippi by way of the Minnesota river, but later, for a somewhat shorter time, its waters were drained towards the north. Apparently, as first pointed out by Winchell, the general northern boundary of Lake Agassiz was the retreating continental ice sheet, and this quite certainly extended near the eastern end of Rainy lake. South of Lake of the Woods

2 **MacMillan.** On the distribution of plants in a fresh-water insular region. Abstract. Bot. Gaz. **22**: 218. 1896.

3 **Upham, W.** Lake Agazziz. Mon. U. S. Geol. Surv. **25.** 1897.

and Rainy lake the glacial body of water was bounded by morainic shores, and Upham has traced the various beaches for many miles in Minnesota, Dakota and Canada.

The somewhat abrupt disappearance of Lake Agassiz, not far from 7000 years ago, left much of its basin to the drainage of the Red and Rainy rivers. Clearly the water, as it abandoned its ancient bed, must have early laid open the southern portion of the valley to plant immigration, and the immigrants must have followed in northward extension the receding inland sea. Since the ice-barrier apparently extended along the eastern shores of what is now Rainy lake, a very sharp distinction arose in those earlier times, and is still to some extent perpetuated between the region within Lake Agassiz and the uninundated, though strongly glaciated area outside its shoreline. Here, it would seem, may be in part the explanation of the rather remarkable dissimilarity between the plant-population of the north shore of Lake Superior, the Mesabi and Giant ranges on the one hand and that of the Rainy lake and Lake of the Woods region on the other. In the latter region many species of plants of southern range are conspicuous, although often dwarfed, or occupying peculiar localities. Indeed the flora of the Lake of the Woods is essentially similar to that of the Red river valley of the Dakotas, and may be regarded as a forest modification of the general north-bound group of plants which established themselves in the bed of the ancient lake. But the plant population of the north shore of Lake Superior—and the formation extends westward to the region south of Gunflint lake and about Vermilion lake—is quite as distinctly an originally northern and south-bound group of plants relatively free from the infiltration of southern forms such as the *Solidagos* and *Apocynums*.

Character of the country rocks and drift.—A detailed account of the geological formations of the Lake of the Woods district would be out of place in this paper as it is rather the physical and chemical character of the soil-components that are of importance, than their faultings and foldings, stratifications and correlations. A full account of the complex geology of the region is given by Lawson[4] and this may be referred to for amplification of the facts brought forward here. The region is one almost entirely of Archaean rocks comprising diorites, augites, felsites, quartzites, granites, diabasic rocks,

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[4] **Lawson:** Lake of the Woods. Rep. Geol. Surv. Can. 1887.

hornblendic and micaceous schists, clay shales, agglomerates, chloritic schists and gneisses. The latter are perhaps the most generally distributed. These rocks classified by Lawson as Keewatin, Laurentian and later irruptive are in certain tracts developed in astonishing variety and the region as a whole gives an opportunity for the formation of most complicated soils. There is, however, an absence of calcic, magnesic and ferric soils with a rather poor development of aluminic soils except in the regions of argillaceous shales or where argillaceous drift has been deposited as is the case at a few points. For the most part the soil, where it exists in quantity, is either humus accumulated in pockets owing to the favorable surface contour of the subtending rocks or a silicious and pebbly drift with but slight admixture of clays. Opportunities for the development of beaches and dunes are, therefore, not wanting, while owing to the general prevalence of rock with but thin drift covering or scant talus formations, bog shores or marshes are rather exceptional.

Types of shores.—There seem to be at Lake of the woods three principal types of shores so far as the substratum is concerned. These I shall denominate.

I. Shores of country rock.
II. Shores of drift.
III. Shores of humus.

Each of these, it is evident, may be subjected to subdivision, and especially is this true of the first two. The following synopsis will give at a glance the classification which has seemed most desirable and convenient for the purposes of this paper.

I. Shores of country rock.
  A. Country rock in place.
    1. Steep precipitous shores.
      a. Creviced rocks.
      b. Smooth rocks.
    2. Rounded shores.
      a. Creviced rocks.
      b. Smooth rocks.
    3. Flat shores.
      a. Creviced rocks.
      b. Smooth rocks.
  B. Talus.
    1. Abrupt and precipitous talus.
    2. Talus extending out over the lake bottom.
    3. Talus with bare crevices (new talus).
    4. Talus with intermixed humus or drift (old talus).

II. Shores of drift.
  A. Boulders and coarse gravel.
    1. With finer drift intermixed.
    2. With humus intermixed.
  B. Sand and fine pebbles.
    1. With slight intermixture of humus.
    2. With marked intermixture of humus.
  C. Clays with sand and pebbles.
    1. With slight intermixture of humus.
    2. With marked intermixture of humus.

III. Shores of humus.
  A. Humus derived from aquatic and semi-aquatic vegetation. Wet humus.
  B. Humus derived from land vegetation. Dry humus.
  C. Mixed humus.

Besides these main types of shore there are, of course, to be considered the very numerous varieties of mixed shores derived from the combinations of two or more of the types givena bove, over the same area. For example, intermixtures of talus and boulders, talus, sand and humus, boulders and humus are altogether frequent, and in walking but a short distance along the shore it is common to encounter more than one or two types of substratum. Especially difficult to classify are the transitional types between shores with rock in place and shores with talus. This is particularly true of those shores such as are seen at Windigo island, where the talus blocks are, many of them, several feet, or even yards, in diameter. In such cases it becomes evident that a certain sufficient size of talus blocks must afford practically the conditions of rock in place.

A chemical classification should perhaps be added to the physiographic one which has been given, but the complexity of the problems, owing to the great variety of rocks, are such as to make only the more general classifications available or practicable. The shore lines may accordingly be denominated thus:

1. Silicious shores.
2. Aluminous shores.
3. Nitrogenous shores.

The first and third are abundant, while the second is scarcely to be found within the area of my observations. In the first group are included the beaches and dunes, the talus or boulder shores, where the derivaties have been from silicious granites, quartzites or gneisses, and the rock shores in which silicious rocks are the prominent components. The third group comprises the various types of humus soils and mixtures in

which humus is the important component. It need scarcely be said that these three groups are not named in an exclusive manner, and that, as a matter of course, nitrogenous components are found in the silicious and aluminous soils as well as in the so-called nitrogenous. The notion is simply to indicate certain preponderances and to give characteristic and appropriate terms to three important soil-types as found on the shore areas at the Lake of the Woods. In this region, as has been indicated above, certain varieties of soil are conspicuous rather by their rarity or absence. For example, ferric, magnesic, calcic, saline and alkaline soils are either wholly absent from the region studied, or quite inconspicuous and unimportant. Ferric soils are abundant, however. farther east, especially upon the iron ranges; calcic and magnesic soils prevail in the southern limestone regions of Minnesota, and saline, alkaline or sodic and potassic soils are developed occasionally in western Minnesota.

By no means all of the important factors in the classification of shore areas have yet been recognized in the attempt in brand. Besides the chemical and general physiographic groups that have been defined there are a number of groups which depend for their distinctive characters upon a mixture of conditions rather difficult to bring together in an orderly analysis. Possibly a series of groups blocked out with reference to the special conditions in each case involved may be noted in serial order and thus the problems may be best appreciated.

I. Classification of shores with reference to illumination.

A. Shores with stronger illumination.

1. Shores facing S. E., S. or S. W.
2. Shores of which the slope approaches a plane perpendicular to the incident rays of sunlight.
3. Shores not subjected to shadows from neighboring objects, such as trees or adjacent shores.
4. Shores upon which light is reflected by adjacent objects such as mounds of white sand or smooth surfaces of light colored rock.

B. Shores with weaker illumination.

1. Shores facing N. E., N. or N. W.
2. Shores of which the slope varies from a plane perpendicular to the incident rays of sunlight.
3. Shores subjected to periodic or permanent shadows from neighboring objects.
4. Shores upon which light is not reflected by neighboring objects.

II. Classification of shores with reference to temperature.

A. Warmer shores.

1. Shores facing S. E., S. or S. W.
2. Shores of which the slope approaches a plane perpendicular to the incident radiations from the sun.
3. Shores not subjected to shadows from neighboring objects.
4. Shores upon which heat is reflected from adjacent objects.
5. Shores composed of dark colored materials which absorb and retain the heat rays of the sun.
6. Shores of a texture unfavorable to rapid evaporation of moisture.
7. Shores sheltered from abundant air-currents which would promote evaporation of moisture.
8. Shores of which the contour or situation produces unfavorable opportunity for the cooling action of rain, dew, surf, spray or running water.
9. Shores bordering sheltered and limited areas of water in passing over which the air currents are not appreciably cooled.

B. Colder shores.

1. Shores facing N. E., N. or N. W.
2. Shores of which the slope varies from a plane perpendicular to the incident radiations of the sun.
3. Shores subjected to shadows from neighboring objects.
4. Shores upon which heat is not reflected by adjacent objects.
5. Shores composed of light colored materials which reflect and radiate rapidly the heat rays of the sun.
6. Shores of a texture favorable to rapid evaporation of moisture.
7. Shores exposed to abundant air-currents, promoting evaporation of moisture.
8. Shores of which the contour or situation produces favorable opportunity for the cooling action of rain, dew, surf, spray or running water.
9. Shores not bordering sheltered and limited areas of water, but facing broad expanses over which air currents, in passing, become cooled.

III. Classification of shores with reference to moisture.

A. Moister shores.

1. Shores crossed by gullies or streams, debouching upon them and conveying moisture or retaining it in pools.
2. Shores favorably exposed to rains, dews or drifting snows.
3. Shores situated where surf or spray is thrown landward, either owing to the direct impingement of prevailing winds, or by reason of the broad expanse of water off-shore.
4. Shores upon which ice-floes are deposited in early spring, owing to their outline, slope, or exposure to the prevailing winds.
5. Shores from which the evaporation of moisture is retarded by shading, or by seclusion from atmospheric currents.
6. Shores, the texture of which favors the retention of rain, dew, surf, spray, snow, ice or running water.

B. Drier shores.

1. Shores not easily wet by water or capable of rapid drainage.
2. Shores unfavorably exposed to dews, rains and drifting snow.
3. Shores protected against the deposition of surf and spray.
4. Shores of which the outline, slope or exposure is unfavorable to the deposit of ice floes in early spring.
5. Shores from which the evaporation of moisture is promoted by exposure to sunshine and atmospheric currents.
6. Shores of which the texture favors the evaporation of rain, dew, surf, spray, snow, ice or running water.

IV. Classification of shores with reference to nutritive value.

A. Nutritive shores.

1. Shores, the components of which are rich in nutritive substances.
2. Shores upon which waters, rich in nutritive substances, debouch from streams or collect from waves.

B. Sterile shores.

1. Shores, the components of which are poor in nutritive substances.
2. Shores upon which waters debouch or waves collect which are poor in nutritive substances.

V. Classification of shores with reference to atmospheric currents.

A. Wind-swept shores.

1. Shores exposed toward the quarter from which come the prevailing winds.
2. High or promontory-like shores.
3. Shores facing wide expanses of water over which the wind has greater sweep.
4. Shores devoid of surface irregularities or growths of vegetation sufficient to break the force of the wind.

B. Sheltered shores.

1. Shores exposed toward quarters from which prevailing winds do not blow.
2. Low or protected shores.
3. Shores facing narrow expanses of water over which the wind has not free sweep.
4. Shores provided with irregularities of surface or growths of vegetation by which the force of the wind is broken.

VI. Classification of shores with reference to mechanical effect of surf.

A. Surf-beaten shores.

1. Shores exposed to wide expanses of water resulting in more continuous surf.
2. Shores of which the slope affords greater impact-force to the surf.
3. Shores exposed toward the quarter from which prevailing winds are accustomed to blow.

4. Shores, the contour of which permits the surf to affect a broader area.

5. Shores facing water of which the depth and character of the bottom favors surf formation. Such shores are subjected to *heavy* surf.

6. Shores provided with moveable bodies which, carried in the surf, increase its impact-force. Among such bodies are flat pebbles and drift-wood.

7. Shores devoid of surf-barriers such as outlying bars or formations of surf-plants.

B. Shores protected against surf.

1. Shores exposed to narrow expanses of water upon which the surf is intermittent.
2. Shores of which the slope diminishes the impact-force of the surf.
3. Shores exposed toward quarters from which the prevailing winds are unaccustomed to blow.
4. Shores of which the contour limits surf action to a narrow area.
5. Shores facing water of which the depth and character of the bottom tends to inhibit surf-formation. Such shores are exposed to *light* surf.
6. Shores destitute of moveable bodies which carried in the surf would increase its impact-force.
7. Shores provided with surf-barriers.

VII. Classification of shores with reference to mechanical effect of ice.

A. Ice-modified shores.

1. Shores of which the exposure, slope, shadiness, coldness and seclusion from winds permit long continued ice-pressure extending into the late spring.
2. Shores of which the contour and slope favor ice-pressure.
3. Shores of a texture readily modified by ice-action.

B. Ice un-modified shores.

1. Shores of which the exposure, slope, sunniness, warmth and accessibility to winds prevents long-continued ice-pressure extending into the late spring.
2. Shores of which the contour and slope minimize the ice-pressure.
3. Shores of a texture not easily modified by ice-action.

VIII. Classification of shores with reference to currents of water.

A. Current-modified shores.

1. Shores bordering upon strong currents.
2. Shores of a texture easily modified by currents.

B. Current-unmodified shores.

1. Shores bordering upon weak currents.
2. Shores of a texture not easily modified by currents.

IX. Classification of shores with reference to soil currents.

A. Crumbling shores.

1. Precipitous shores upon which the force of gravity acts strongly.
2. Shores of a texture readily broken.
3. Shores exposed to strong weathering influences.

B. Firm shores.

1. Low or rounded shores upon which the components are disposed in stable equilibrium.
2. Shores of a firm and resistant texture.
3. Shores protected from strong weathering influences.

X. Movable shores.

A. Shores moved by the wind: e. g. Sand dunes.
B. Shores moved by wind and water: e. g. Floating bogs.
C. Shores moved by water: e. g. Beaches facing currents or eddies.

The ten groups of shore-types given above scarcely exhaust the possibilities of instructive classification but the more important groups have been included in the scheme. It becomes evident that the consideration of a given shore must include a wide variety of judgments and observations and in any given example of shore a large number of factors must be taken into account before a reasonably complete comprehension of it as a station for plant individuals or plant formations can be formed in the mind. Its exposure, contour, slope, texture, color, chemical composition, physical structure, temperature, moisture, nutriment content, illumination must all be given due consideration. The influence upon it of rains, dew, snow, ice, surf, spray, wind, currents of water or of soil and the force of gravity must be regarded, and since not one condition alone but permutations of all of the conditions in varying degree are in every case to be distinguished, it would seem that a reasonable explanation of the endless diversity of landscape might very well lie in the diverse qualities of the substratum upon which vegetation disposes itself. But when to all this is added the endless complexity of biological factors—the symbioses, the struggles between individuals and formations, the ecological adaptations and distribution devices, the hybridizings and all the historical, developmental and evolutional phenomena—the student may well hesitate, so interminable is the coil. Yet if the theoretical possibility of complete explanation under conditions of complete comprehension of the data be taken into the mind much has been accomplished. The position of a given plant or of a particular formation at some spot on the crust of

the earth, no longer seems a matter of chance but rather the definite result of definite, although endlessly complicated causes.

Advantages offered by a fresh-water archipelago in the study of ecologic distribution.—It has long impressed the writer that a lake with numerous islands offered one of the best fields for research in ecologic distribution and with this belief in mind, Lake of the Woods was selected as a peculiarly excellent body of water for study. The advantages are many. Portions of land of convenient size for careful and exhaustive examination are, in such an archipelago, isolated one from another by areas of water. Lake of the Woods offers a wide variety of shore-lines varying from the mud-flats of the mouth of Rainy river and Muskeg bay to the sand-dunes of the Isle aux Sables, the extended beaches of Oak point and the Northwest Angle, the drift mantled shores of Garden island, the rounded rocks and talus heaps of the smaller American islands and the cliffs and crags of the Crow rock and Shoal lake islands. Almost every kind of shore-line from floating bog to precipice may be observed, and, from the exceptional shape of the lake, exposures to narrow, secluded channels, through which the frail canoe of the Indian or the voyageur creeps with difficulty, may be considered at one point, while at another one may stand before a roaring surf without even a distant haze of land visible at the horizon's edge. But for the monotony of its silicious soils such a lake with its thousands of islands, its cliffs and morasses its winding bays and its Grand Traverse would be an ideal spot for the solution of most of the intimate problems of ecologic distribution.

DERIVATION OF THE PLANT POPULATION.

General considerations.—It may be laid down as a law of plant distribution that the *kinds* of plants in a region depend upon general causes originating at a distance and of long duration, while the *position*, *number* and *strength* of plants depend upon local causes of shorter duration. Thus the *presence* of the white pine, *P. strobus*, in the Lake of the Woods region rather than *P. taeda* of more southern and eastern range results from a long evolutional history, to comprehend which thoroughly would require an extended survey of vegetation conditions both of to day and of the past, over a great portion of the continent of North America. But the *position* of plants of *P.*

strobus on the richer soil of crevices or on clayey loams rather than upon barren rocks or sand or in marshes or swamps is largely a matter of topography. Before proceeding, then, to an analysis of the different plant formations established along shore at Lake of the Woods, it will be well to observe in a general way what species of plants have taken possession of the region. It is not by any means my intention to furnish here a long list of species and varieties; all that will be necessary to exhibit is a list of dominant plants on a few selected shores. Four such shores have been chosen. Of these Oak point is near the mouth of the Rainy river and faces the surf of the Grand Traverse towards the N. W. while toward the S. E. it is washed by the waters of a quiet bay. Sandy beach is opposite Garden Island, on the Northwest Angle and the back country is almost entirely composed of impassable spruce and tamarack swamps or muskeg. Isle aux Sables is the name given to what is really a chain of sand dunes lying near the S. E. shore of the lake and north of the mouth of the Rainy river. Big island point is the N. W. point of this island about due E. of Garden Island. It is a high rocky promontory clothed with mosses and lichens but with many crevice plants of higher types.

List of dominant plants established on four selected shores.

N., of Northern Range. S., of Southern Range. C., of Continental Range.	Oak point.	Sandy beach.	Isle aux Sables.	Big island point.
N. Dryopteris spinulosa (Retz.) Kze	*			
N. —— thelypteris (L.) A. Gray				*
N. Polypodium vulgare L				*
C. Equisetum arvense L	*			
N. —— hiemale L	*			
N. Juniperus sabina L			*	*
N. —— communis L	*		*	*
N. Picea mariana (Mill.) B. S. P	*			
N. Pinus divaricata (Ait.) Sudw	*		*	
N. —— strobus L	*			
N. —— resinosa Ait	*		*	
N. Taxus minor (Michx.) Britt	*	*		*
C. Typha latifolia L	*			
N. Potamogeton foliosus Raf	*			
N. —— heterophyllus Schreb	*			
N. —— perfoliatus var. richardsonii Benn	*			
C. Sagittaria arifolia Nutt		*		
S. —— graminea Michx	*			
S. —— latifolia Willd	*			
S. —— rigida Pursh	*	*		
N. Agropyron tenerum Vasey	*	*		*
N. Agrostis alba L	*	*		*
C. —— hiemalis (L.) B. S. P	*	*	*	*
C. Alopecurus geniculatus L	*			
N. Calamagrostis canadensis (Michx.) Beauv	*	*	*	
C. Elymus canadensis L	*	*	*	*
N. Hordeum jubatum L	*			
N. Graphephorum melicoideum (Michx.) Beauv		*		
S. Muhlenbergia mexicana (L.) Trin				*
S. Panicum dichotomum L	*			*
N. Carex canescens L				*
N. —— filiformis L	*	*	*	
C. —— riparia W. Curtis		*		
C. —— scoparia Schkr	*	*	*	
N. —— siccata Dew		*		
S. Cyperus inflexus Muhl		*		
N. —— schweinitzii Torr		*		
C. —— strigosus L				*
C. Eleocharis palustris (L.) R. & S	*		*	
C. —— tenuis (Willd.) Schultes	*		*	
N. Scirpus cyperinus (L.) Kunth	*	*		
C. —— lacustris L	*			
C. Lemna minor L	*			
N. Juncus articulatus L	*			
N. —— balticus Willd	*	*		
N. —— canadensis J. Gay			*	
C. —— tenuis Willd			*	*
S. Polygonatum commutatum (R. & S.) Dietr	*			
S. Smilax herbacea L	*			*
N. Unifolium canadense (Desv.) Greene		*		
N. Vagnera stellata (L.) Morong	*	*		
S. Iris versicolor L	*	*		
C. Habenaria psycodes (L.) A. Gray		*		
N. Populus balsamifera L	*			
C. —— deltoidea Marsh	*			
N. —— tremuloides Michx	*	*	*	
C. Salix discolor Muhl		*	*	
N. —— fluviatilis Nutt	*			
N. —— lucida Muhl	*		*	
N. —— myrtilloides L			*	
N. —— petiolaris J. E. Smith			*	
N. —— petiolaris var. gracilis Anders	*			
N. Betula glandulosa Michx		*		
C. Quercus macrocarpa Michx		*	*	*
S. Celtis occidentalis L			*	
N. Comandra umbellata (L.) Nutt	*			
N. Polygonum cilinode L		*		
S. —— erectum L	*			
S. —— emersum (Michx.) Britt	*	*		
C. —— hartwrightii A. Gray		*		
C. Chenopodium album L	*			
N. —— leptophyllum (Moq.) Nutt	*			
N. Corispermum hyssopifolium L		*		
S. Allionia nyctaginea Michx	*		*	
N. Arenaria stricta Michx	*			
N. Cerastium arvense L		*		
S. Silene antirhina L	*			
S. Castalia odorata (Dryand.) Woodv. & Wood			*	

List of dominant plants established on four selected shores.

N., of Northern Range. S., of Southern Range. C., of Continental Range.		Oak point.	Sandy beach.	Isle aux Sables.	Big island points.
N.	Actaea alba (L.) Mill				*
N.	Anemone canadensis L.				*
N.	Ranunculus macounii Britt				*
N.	—— pennsylvanicus L. f	*	*		
S.	Capnoides micranthum (Engelm.) Britt	*			*
N.	Arabis brachycarpa (T. & G.) Britt	*	*		
N.	—— hirsuta Scop	*			*
C.	Bursa bursa-pastoris (L.) Weber	*			
N.	Lepidium apetalum Willd	*			
C.	Roripa palustris (L.) Bess	*			
S.	Heuchera americana L				*
N.	Ribes oxycanthoides L		*		
S.	Amelanchier canadensis (L.) Medic		*		
N.	Cerasus pennsylvanica L. f		*	*	
C.	—— virginiana (L.) Loisel	*			*
N.	Fragaria vesca L		*		
C.	Potentilla arguta Pursh	*	*	*	*
C.	Prunus pumila L	*	*	*	
N.	Rosa blanda Ait		*		*
C.	——woodsii Lindl	*	*		
N.	Rubus strigosus Michx	*	*	*	
N.	Sorbus sambucifolia (C. and S.) R.		*	*	
N.	Spiraea salicifolia L.	*	*	*	*
N.	Lathyrus maritimus Bigel	*		*	
S.	Oxalis stricta L				*
S.	Rhus glabra L	*			
S.	—— radicans L	*	*	*	
C.	Celastrus scandens L	*			
S.	Acer negundo L.		*		
C.	Impatiens aurea Muhl		*		
S.	Parthenocissus quinquefolia (L.) Planch	*	*		
S.	Vitis vulpina L	*			
N.	Hypericum ellipticum Hook		*	*	*
N.	—— majus (A. Gray) Britt		*		
C.	Hudsonia tomentosa Nutt			*	
C.	Chamaenirion angustifolium (L.) Scop		*		*
N.	Epilobium adenocaulon Haussk	*			
N.	—— lineare Muhl		*		
C.	Onagra biennis (L.) Scop		*	*	*
C.	Aralia racemosa L				*
N.	Cornus baileyi Coult. & Evans	*	*		
S.	—— sericea L		*	*	
N.	Arctostaphylos uva-ursi (L.) Spreng	*			
C.	Lysimachia terrestris (L.) B. S. P		*		
N.	Naumburghia thyrsiflora (L.) Duby		*		
S.	Fraxinus americana L	*	*	*	
N.	Menyanthes trifoliata L		*		
S.	Apocynum cannabinum L	*			
N.	Convolvulus sepium L		*		
S.	Verbena hastata L				*
C.	Lycopus sinuatus Ell	*	*		
N.	Mentha canadensis L	*			
S.	—— sativa L				*
N.	Scutellaria galericulata Michx	*	*		
N.	—— lateriflora L	*			
S.	Stachys aspera Michx		*		*
C.	—— palustris L	*	*		
S.	Vleckia anethiodora (Nutt.) Greene				*
C.	Utricularia vulgaris L	*	*		
S.	Plantago major L				*
N.	Galium boreale L				*
C.	—— trifidum L	*	*		
N.	Lonicera dioica L				*
N.	Sambucus pubens Michx			*	
N.	Campanula aparinoides var. grandiflora Holzing		*		
C.	—— rotundifolia	*		*	*
C.	Ambrosia artemisiaefolia L				*
S.	—— psilostachya DC				*
C.	Artemisia canadensis Michx	*	*	*	
S.	—— caudata Michx	*	*	*	
C.	Erigeron canadensis L	*			
S.	—— ramosus (Walt.) B. S. P	*	*		
S.	Eupatorium perfoliatum L		*		*
N.	Euthamia graminifolia (L.) Nutt				*
N.	Hieracium canadense Michx				*
N.	—— scabrum Michx	*			
N.	Solidago juncea Ait	*	*	*	
C.	Lactuca canadensis L				*

The above list by no means includes all of the important littoral plants of the Lake of the Woods region and longer exploration especially on the Isles aux Sables would bring to light numerous other species. Yet since equal areas were covered at the different localities and the collections made with equal care in all cases, it may be fairly maintained that the list represents properly the varieties of dominant plants established upon the four kinds of shore in question. Such a list, however, gives no exact idea of the vegetation of the shores it purports to cover, for the relative abundance of individuals is not taken into account, nor the groupings in formations, nor robustness of growth. For example, *Populus tremuloides* listed for Sandy beach and Isle aux Sables constitutes an entirely different formation at the one shore as compared with the other. Upon the dunes it appears as a loose, open, scattered formation of low shrubs while at the beach it forms a zone of tall trees at the back strand where the wind, the waves and the ice have thrown up a ridge of sand and gravel. Such a list is of interest principally because it gives the student of distribution an idea what general influences have acted in the population of the territory in question, and because it may serve as a foundation for some of the special ecological lists yet to be offered.

Relationships of the group.—In the above list of 156 species, 78 or 50 per cent. are of distinctively northern range, 36 or 22 per cent. are of distinctively southern range, while 42 or 28 per cent. are of continental range and might properly be counted with either group. Evidently this list of dominant species indicates a generally northern character in the Lake of the Woods population. But it must be remembered that but very few of the plants are distinctive of high northern latitudes. Excluding such forms as *Juniperus sabina*, *Betula glandulosa*, *Salix myrtilloides*, *Ribes oxycanthoides*, *Sorbus sambucifolia* and *Arctostaphylos uva-ursi*, the remainder are in large part characteristic plants of the prairies and woods of Minnesota, Iowa and the Dakotas. Indeed when such a list is compared with those which have been made by Arthur, Bailey and Holway[5] for the Vermilion lake and Hunter's island region of Lake Superior drainage, and by the writer for the valley of the Minnesota[6] it is at once recognized that the

5. **Arthur. Bailey and Holway.** Bull. Geol. & Nat. Hist. Sur. Minn. No. 3. 1887.

6. **MacMillan.** Metaspermae of the Minnesota valley. Rep. Bot. Sur. Minn. I. 1892.

affinities of the Lake of the Woods population are rather with the general group of plants distributed throughout the Red river valley and in southern Minnesota than with the series lying in the same latitude but to the eastward of the Rainy lake region. Bailey's list of plants collected on Hunter's island is especially instructive in this comparison. In this list of 80 species such varieties as *Carex lenticularis, Aster macrophyllus, Spiranthes gracilis, Alnus viridis, Geum nivale, Habenaria orbiculata, Alnus incana, Gaultheria procumbens, Myrica gale, Corylus rostrata, Anaphalis margaritacea, Thuya occidentalis* and others serve to indicate the strong northern character of the plant population of this district. And upon the shores of Lake Superior where such genera as *Pinguicula, Ribes, Drosera, Diervilla, Antennaria* and *Pyrola* are strongly developed in number of individuals a quite different cast is given to the general flora. This is to be explained without doubt as in part a result, as has been indicated above, of the recession of the waters of the glacial lake Agassiz from south to north, thus opening up the ancient bed to infiltration of southern forms. Thus there may be observed the very interesting occurrence of *Celtis occidentalis* for example on the dunes at Lake of the Woods where it grows in company with *Sorbus sambucifolia* and *Juniperus sabina.* Similarly interesting is the appearance of *Ambrosia psilostachya* as a dwarfed but characteristic denizen of talus and boulder-drift shores on Big island point, and the abundance of southern species of *Sagittaria* in strand pools, surrounded by *Iris, Polygonatum* and *Allionia.*

DESCRIPTION OF PLANT FORMATIONS.

Classification of formations.—In entering upon a discussion of the variety of formations that may be observed upon shore areas at Lake of the Woods, I shall make use of the division proposed in a recent paper upon the distribution of tamarack and spruce in bogs[7]. Formations may be broadly grouped as ZONAL, where the topographic feature presents a well-marked radial symmetry, and AZONAL, where the topographic feature presents no well-marked radial symmetry. A further

7. **MacMillan.** On the formation of circular muskeg in tamarack swamps. Bull Torr. Bot. Club. **23**: 500. *Pl. 279-281.* 1896.

classification of shore formations under this plan is forthwith presented:

- I. **Zonal formations.**
  - A. Beach or strand.
    - 1. Front strand.
    - 2. Mid-strand.
    - 3. Back strand.
    - 4. Strand pools.
  - B. Dunes.
    - 1. Dune slopes.
    - 2. Dune summits.
    - 3. Dune pools.
  - C. Morasses.
    - 1. Attached morass.
      - *a.* Wet morass.
      - *b.* Dry morass.
    - 2. Detached morass.
      - *a.* Floating bog.
      - *b.* Anchored bog.
  - D. Surf-barriers.
    - 1. Barriers in strong surf.
    - 2. Barriers in light surf.
  - E. Rock shores.
    - 1. Flat rocks.
    - 2. Rounded rocks.
  - F. Soil shores.
    - 1. Flat shores.
    - 2. Rounded shores.
- II. **Azonal formations.**
  - A. Talus shores.
    - 1. Coarse talus shores.
    - 2. Fine talus shores.
  - B. Boulder shores.
    - 1. Coarse boulder shores.
    - 2. Fine boulder shores.
  - C. Rock shores.
    - 1. Irregular surfaced rock shores.
    - 2. Creviced shores.
    - 3. Precipitous shores.
  - D. Humus shores.

A discussion of the particular plant formations, which characterize these different ecologic areas will now be presented.

STRAND.

Front strand.—The zone of vegetation denominated front strand, is that group of plants established nearest the water's edge. Between the mid-strand group and the water of the lake is a narrower or wider strip upon which vegetation is unable to establish itself, except in the case of the lower plants such as *Aphanizomenon flos-aquae*, for example. The width of the barren strip depends upon the force of the surf. In this area small strand pools, tenanted by algae in some cases, will form between successive seasons of surf-impact. The transitory pools can furnish an area for the development only of very simple and short-lived organisms. Various species of algae may complete their reproductive processes in such pools of the front strand and the region of the beach closest to the water's edge must be regarded as occupied by an interrupted zone of algal forms. In some cases after a heavy wind such pools will be crowded with Cyanophyceae to such an extent as to make the zone exceedingly conspicuous, but after a few days of sunshine and surflessness the pools will evaporate, and the spores alone of the algae will retain their vitality. Some of these spores will be washed out into the lake with the next season of surf, while the majority will be buried in the sand. The pools of the front strand are therefore characterized by a special vegetable formation, transitory as is its habitat and of lowly types. In high surf these algae contribute to the nitrogenous content of the mid-strand.

Mid-strand.—Extending from the front strand near the water's edge back to the higher beach upon which the surf never dashes, is commonly a shelving area bearing a very characteristic group of plants. Its breadth varies with its inclination, its texture, the strength of the surf and the character of the bottom off-shore. This area is at long intervals subjected to strong spray or even light surf and to occasional inundation. Such an exposure may not arise for several seasons and, when it comes, depends upon unusual height of water and continuous winds. Hence a group of plants, very many of which are annual, although some are perennial, establish themselves upon the strip. This band of occasionally inundated beach may be known as *mid-strand.* It is characterized by relatively scanty and dwarfed development of trees or shrubs except in the case of such as bear with ease submersion for a season—as for example, *Salix, Cornus, Prunus pumila, Populus tremuloides.*

Shrubs like *Sorbus*, *Rosa*, *Vitis*, and others that do not endure well an occasional submersion are altogether absent from the mid-strand. A list of mid-strand vegetation at Oak point is presented here.

Mid-strand group at Oak Point.

Equisetum arvense.	Chenopodium leptophyllum.
Equisetum hiemale.	Arenaria stricta.
Agropyron tenerum,	Capnoides micranthum.
Agrostis alba.	Arabis hirsuta.
Elymus canadensis.	Bursa bursa-pastoris.
Hordeum jubatum.	Lepidium apetalum.
Panicum dichotomum.	Prunus pumila.
Carex filiformis.	Potentilla arguta.
Juncus articulatus.	Spiraea sa icifolia.
Juncus balticus.	Lathyrus maritimus.
Populus tremuloides.	Epilobium adenocaulon,
Salix fluviatilis.	Artemisia canadensis.
Salix lucida.	Artemisia caudata.
Salix petiolaris var. gracilis.	Erigeron canadensis.
Chenopodium album.	Solidago juncea.

For comparison there is also given the mid-strand population observed across the lake at Sandy beach on the Northwest Angle.

Mid-strand group at Sandy Beach.

Agropyron tenerum.	Prunus pumila.
Agrostis alba.	Spiraea salicifolia.
Agrostis hiemalis.	Hypericum ellipticum.
Elymus canadensis.	Chamaenirion angustifolium.
Carex filiformis.	Epilobium lineare.
Carex scoparia.	Onagra biennis.
Carex siccata.	Cornus baileyi.
Juncus balticus.	Cornus sericea.
Populus tremuloides.	Convolvulus sepium,
Betula glandulosa.	Campanula aparinoides var. grandiflora.
Polygonum hartwrightii.	Artemisia canadensis.
Corispermum hyssopifolium.	Artemisia caudata.
Cerastium arvense.	Solidago juncea.
Potentilla arguta.	

These two lists do not give a proper idea of the difference between the two beaches, for it lies less in kinds of plants than in the types which are abundantly developed. It will be observed that such characteristic sand plants as *Agropyrum tenerum*, *Elymus canadensis*, *Artemisia caudata* and *Artemisia canadensis*, are present in each case. As a matter of fact, the Oak point mid-strand is characterized by the strong development of *Prunus pumila*, *Lathyrus maritimus* and *Populus* scrub with *Juncus* and *Salix* abundant as secondary plants. But the Sandy beach mid-strand is characterized by the prevalence of *Cornus baileyi* and *Cornus sericea* with *Convolvulus*, *Onagra* and *Chamaenirion*. These larger leaved plants indicate a reaction in the plant population to the quieter, less wind-swept character

of the Northwest Angle shore. Without question Oak point is one of the most wind-swept points on the whole lake, and the dwarfed types of plants which are established upon the mid-strand would seem to be a reaction to such an exposed situation. Two types of mid-strand may therefore be defined, with reference to adaptation to prevailing winds.

I. *Prunus* mid-strand. *Prunus pumila*, the dominant and characteristic plant. Example, the Oak point midstrand. (*Plate LXXI.*)

II. *Cornus* mid-strand. *Cornus sericea* and *Cornus baileyi*, the dominant and characteristic plants. Larger *Salix* shrubs and special twining and shade-loving plants are also established upon such a mid-strand. Example, the Sandy beach midstrand. *Plate LXXII*, in the background, shows this type of mid-strand as developed on the sheltered side of Isle aux Sables.

A third type should be added, according to my observations on mid-strand in quieter bays. For example, on the north side of Garden island, shielded from the winds and waves of the Grand Traverse, and enclosed from most of the surf and white caps of the Little Traverse, is a bay with finely developed mid-strand upon which *Salix fluviatilis* is the dominant plant. This is a very level and gently sloping beach, and at the back other species of *Salix*, *S. discolor*, *S. nigra* and *S. amygdaloides*, form an abundant growth. The beach is exposed to rather frequent inundations, but to slight wind action or surf-impact. The peculiar prevalence of the *Salix fluviatilis* formation may be regarded as a response to this group of conditions.

III. *Salix* mid-strand. *Salix fluviatilis*, the dominant and characteristic plant; but few other species, e. g. *Capnoides micranthum*, *Chenopodium album*, *Polygonum ramosissimum*, established. Example, the northeast bay of Garden island (*Plate LXX.*)

The three types of mid-strand appear to be practically the only types that can be isolated over all the beach area that I have studied at Lake of the Woods. That there should be three types, 1, a group of numerous, low, small leaved forms, the *Prunus* mid-strand; 2, a group of numerous, higher, many of them large leaved forms, the *Cornus* mid-strand; and, 3, a group of homogeneous low plants, long leaved, deep rooted, the *Salix* mid-strand, is connected, I believe, with three different groups of conditions. Thus it would appear that strong wind, occasional light surf and almost continuous spray favors the devel-

opment of Type I, the *Prunus* mid-strand. Generally light winds, light surf, and less continuous spray favor the development of Type II, the *Cornus* mid-strand. Light winds, light surf, and frequent inundation favor the development of Type III, the *Salix* mid-strand.

It is interesting to notice that when strand formations of this character are developed on both sides of a narrow spit as at several different localities at Lake of the Woods, the side exposed to the strong prevailing winds is more abundantly provided with plants of *Prunus pumila* while it is upon the less exposed side that one must look for the *Cornus* bushes in greater number. And this difference between the two sides of a sand spit will vary about with the inclination of the spit towards a direction perpendicular to the prevailing winds.

A number of conditions may modify the mid-strand formations; the important ones are exertion of ice pressure and formation of surf barriers off shore. By the former it not infrequently happens that a ridge is piled up at the water's edge in early spring and surf then forms mid-strand pools which may be permanent for a series of years. The establishment of such pools brings about a rearrangement of vegetation which will be discussed more particularly under the head of strand pools. And from this original exertion of ice pressure various secondary changes in the mid strand may be initiated, so that the whole aspect of the plant population is changed. For example, if the mid-strand is wide, such a formation of strand pools may eventually result in the appearance of dunes, sand-fixing plants gaining a particularly favorable opportunity for work at the borders of the pool. And if surf barriers, which continue in place for a number of years, are developed, the mid strand may take much the aspect of back strand, plants creeping down upon it which are unable to maintain themselves through seasons of surf or inundations to which the mid-strand was generally exposed before the barrier had appeared. Such surf barriers may be in the nature of sterile impermanent bars or they may become the habitation of surf plants and they may eventually, as in the case of the Isle aux Sables, develop into a conspicuous and permanent dune:

The light color of the mid-strand, owing to the slight development of humus, contributes to the dwarfed habit of the plants growing upon it by reducing the temperature of the substratum. Such areas become cold soon after sundown while the back strand still remains warm. By midnight the tempera

ture of the mid-strand will have fallen several degrees below that of the back strand, as observations made in 1894 very clearly indicated. The occasional inundations, surf, winds and spray all combine both directly and indirectly to lower the temperature of the mid-strand substratum so that plants requiring a somewhat higher root temperature like *Polygonatum, Viola, Anemone, Vagnera,* do not in this region venture down upon the light cold sands, but remain where intermixture of humus, shelter from winds and evaporation, and darker color of the soil, all cooperate in preserving more nearly an optimum temperature.

In general the mid-strand area studied at different points on Lake of the Woods appears to afford an excellent example of the sensitiveness of plant formations to varying environmental conditions. The character and aspect, the abundance or paucity of certain forms, the arrangement of the different forms with reference to one another all seem definitely conditioned upon the variations in exposure, slope, temperature, moisture, wind-currents and surf-impact, or upon combinations or modifications of these. So the constant variety of the beach as one walks along it is connected with the multitude of variations in the soil below, the air above and the water off shore. The mid-strand, too, is modified by the back strand which abuts upon it. By the population of the back strand its own is changed, and by the struggle that goes on in the back strand the mid-strand may in time be affected, as when rows of trees grow to a great height on the back strand thus shading a portion of the mid-strand. And by the physical texture and contour of the back strand, the mid-strand may be affected very sharply—as when the rain is carried through gullies in the back strand down upon or across the area nearer the water's edge. Curious interrupted patches of *Carices* and *Epilobiums* that occur in the mid-strand are often to be referred to declivities or gullies of the back strand, directing the moisture to some spots rather than to others. Thus both the physical and biological conditions of the zone farther inland affect the beach flora quite as distinctly as do the conditions shoreward.

Back strand.—The back strand is commonly marked by a considerable rise in elevation and must generally be regarded as developed principally by the activity of the wind rather than by the surf or ice. Such ridges behind the mid-strand are usual, and in some cases no doubt are of more ancient develop-

ment and indicate a former higher level of the lake. Back strand may be defined as elevated beach formation rising at the rear of the mid-strand. It is always characterized by a much higher per cent. of humus in the soil, consequently by soil of a darker color, although in many cases the difference is slight. Yet even back strand composed apparently of pure sand will upon comparison with the mid-strand or front strand appear distinctly darker in color. Consequently it becomes the abode of those plants which have more of a thermophytic or nitrophytic character. Yet if the sand be still the principal constituent of the soil as is ordinarily the case a peculiar grouping of plants, sometimes reminding one directly of the sand-dune formations, arises. A list of plants of the back strand is here appended, taken from observations on Oak point.

Back strand Group at Oak Point.

Dryopteris spinulosa.
Equisetum arvense.
Juniperus communis.
Picea mariana.
Pinus divaricata.
—— strobus.
—— resinosa.
Taxus minor.
Agrostis alba.
Alopecurus geniculatus.
Calamagrostis canadensis.
Polygonatum commutatum.
Smilax herbacea.
Vagnera stellata.
Populus balsamifera.
Populus deltoidea.
Populus tremuloides.
Comandra umbellata.
Polygonum erectum.
Silene antirhina.
Ranunculus pennsylvanicus.
Arabis brachycarpa.
Cerasus virginiana.
Rosa woodsii.
Rubus strigosus.
Rhus glabra.
Rhus radicans.
Celastrus scandens.
Parthenocissus quinquefolia.
Vitis vulpina.
Cornus baileyi.
Arctostaphylos uva-ursi.
Fraxinus americana.
Apocynum cannabinum.
Lycopus sinuatus.
Mentha canadensis.
Scutellaria galericlata.
—— lateriflora.
Stachys palustris.
Galium trifidum.
Campanula rotundifolia.
Erigeron ramosus.
Hieracium scabrum.
Solidago juncea.

Another example of back strand, quite clearly distinguished from the country behind it, was examined at Sandy beach, and the list of its dominant plants is appended.

Back strand group at Sandy beach.

Taxus minor.
Agrostis alba.
Calamagrostis canadensis.
Graphephorum melicoideum.
Carex riparia.
Carex siccata.
Cyperus inflexus
—— schweinitzii.
Unifolium canadensis.
Vagnera stellata.
Habenaria psycodes.
Populus tremuloides.
Salix discolor.
Beluta glandulosa.
Quercus macrocarpa.
Polygonum cilinode.
Cerastium arvense.
Ranunculus pennsylvanicus.
Arabis brachycarpa.
Ribes oxycanthoides.
Amelanchier canadensis.
Cerasus pennsylvanica.
Fragaria vesca.
Rosa blanda.
Rosa woodsii.
Rubus strigosus.
Sorbus sambucifolia.
Rhus radicans.
Acer negundo.
Impatiens aurea.
Parthenocissus quinquefolia.
Hypericum ellipticum.
—— majus.
Epilobium lineare.
Lysimachia terrestris.
Naumburghia thyrsiflora.
Fraxinus americana.
Convolvulus sepium.
Scutellaria galericulata.
Stachys aspera.
—— palustris.
Galium trifidum.
Erigeron ramosus.
Eupatorium perfoliatum.
Solidago juncea.

Back strand formations at Lake of the Woods may be instructively classified into three general groups:

I. Herbaceous back strand.
II. Shrubby back strand.
III. Arboreal back strand.

Each of these main types may be subdivided as one or another variety of plant gives the characteristic appearance to the formation as a whole. Yet there are not so many principal types as one would suppose. The following synopsis brings out what I think are the principal and most important subgroups.

I. Herbaceous back strand.
  a. Gramineous back strand.
  b. Mixed herbaceous back strand.
II. Shrubby back strand.
  a. Coniferous back strand.
  b. *Populus* back strand.
  c. *Salix* back strand.
  d. *Cerasus* and *Rosa* back strand.
  e. Mixed shrubby back strand.
III. Arboreal back strand.
  a. Coniferous back strand.
  b. *Populus* back strand.
  c. *Salix* back strand.
  d. *Quercus* back strand.
  e. Mixed arboreal back strand.

The conditions which determine the character of the back strand group of vegetation are more complex than those which determine the mid strand character, but for clearness they may be considered under three heads. 1. Conditions which originate in the back strand itself. 2. Conditions which arise lakeward. 3. Conditions which arise landward. Of the first group of conditions, those that originate in the back strand itself, a division into chemical, physical and biological, may be made with value, and these may be reviewed in order. The most important chemical difference between back strand and mid-strand lies in the greater percentage of nitrogenous material which is mingled with the sand. This serves to make back strand more nutritive, as a substratum, than the areas nearer the water's edge. Hence plants of more nitrophytic habit can become established upon it, as, for example, *Vagnera* and *Smilax.* In typical back strand I do not find that this increment of soil nitrates and nitrites becomes so considerable that true humus plants may gain a foot-hold, and therefore *Corallorhiza* or *Pyrola* are absent from this formation, but the freedom from surf activity tending to wash out organic substances formed in the interstices of the sand and the less rapid drainage off of soil water derived from rains, both contribute to a degree of nitrogen-content that is favorable to special species and groups of species. The larger leaved and more robust habit of the back strand vegetation by diminishing wind activity has also an effect favorable to the retaining of dead leaves upon the surface, which, in course of their decay, add to the nitrogen-content.

Of physical differences the rise in soil temperature, owing to the changes in its texture and color, are doubtless of considerable importance, while the decrease in illumination, owing to the shade-affording bodies which are developed, and the reducing of the general reflection-value of mounds and hummocks must not be ignored. Thus the retention of moisture is promoted, and this is still further accentuated by the withdrawal of the whole area from surf-activity, and the substitution of wind-activity, which tends to develop a more irregular surface with consequent greater tendency to accumulate soil-water. As a whole, the back strand is of higher temperature, less illumination and greater superficial saturation than the mid-strand, and this in a broad way is true, notwithstanding the periodic inundations of the mid-strand. At a considerable depth below the surface, however, the saturation of the mid strand is greater than that of the back strand.

Of biological conditions, which seem to modify the back strand when compared with the mid-strand, the more important are those which originate landward, but there are some which originate in the back strand formation. The influence of shade increases most rapidly in proximity to the areas of greatest moisture, and a competition for light which is somewhat more vigorous than over the drier areas arises among plants established in the favorable areas for robust growth. Hence a segregation of plants into groups may take place, and the struggle between these groups becomes an important factor in the final distribution over the whole formation. Therefore in the back strand, rather than in the mid-strand, one finds such partially dependent plants as *Celastrus*, *Parthenocissus*, *Polygonum cilinode* and *Convolvulus sepium* supporting their weak stems upon the stronger shoots of other plants.

Considering next the second group of general conditions under which the back strand is modified, one may note those conditions which arise lakeward. Of this group the chemical modifications are not so important as the physical and biological. The physical conditions are of two sorts, those physical modifying conditions originating in the mid-strand, and those originating outside the mid-strand zone. The biological conditions, however, originate primarily in the mid-strand.

An important physical modification arising primarily in the mid-strand but affecting the back strand is deposition of sand blown landward by the winds or moved landward by the surf or ice until it becomes a portion of the back strand area. Such encroachment of sand has a tendency to reduce the back-strand group of plants to a level with the mid-strand group. And since this sand is more readily carried along certain paths than others, owing to less resistance of established vegetation or because of favorable surface contour of the back strand, there is a clearly marked isolation of back strand masses of vegetation between successive mid strand strips which have pushed landward. Evidently the breadth of the mid-strand area will be an important factor in this process. If the mid-strand is narrow the process will not be undertaken upon a large scale but with a wide mid-strand belt these infiltrating arms or ribbons, perpendicular to the general mid strand formation are by no means unusual or inconspicuous. The edge of the back strand next the mid-strand is affected also in other ways by the lake formation; for example the reflected glare of the sunshine and the impact-force of fine sand-particles upon plants

which are exposed to their flight, must have a certain influence in determining the character of the line between mid-strand and back strand. And, again, the chilling of the air at night by the rapid mid-strand cooling has doubtless its effect, slight though it may be.

Other physical conditions affecting the back strand, and arising lakeward may scarcely be regarded as having their origin in the mid-strand. An example of such conditions would be the cold wind striking the higher back strand formation owing to its exposure to a large area of water, while in another part of the lake such a wind would be less cold, having passed over a smaller portion of the lake. As the back strand increases in height this influence will become more important. A portion at least of the differences which have arisen between back strand at Oak point, with its stunted *Populus* and *Pinus divaricata* trees, its *Rosa*, *Fraxinus* and *Cerasus* shrubs and back strand at Sandy beach with its tall *Populus* trees and abundant shrub of *Taxus*, *Amelanchier* and *Rhus* may be attributed to the exposure of the Oak point back strand to continuous colder winds than those that strike against Sandy beach. The height above the lake level of the two back strand formations is approximately the same, in the regions studied. Yet the difference in the temperature of the winds received by the two areas during a season must be considerable, amounting without doubt to several degrees. And even a few degrees more or less in annual temperature is of great importance in the effect upon plant development and plant distribution, as may be learned from the numerous phaenological observations. Among other conditions tending to modify the back strand, and falling within this category may be noted spray-action. This affects the back strand especially whenever there is a heavy surf formed under ordinary stress of wind. So at Oak point, where the surf is unusually strong, even upon the back strand during a storm or soon after the storm has passed one may feel the fine spray drifting inland. If this surf-spray is frequently carried across the mid-strand—the region of its greatest influence—alterations in the vegetable formations of the back strand will result. The lowering of the temperature, the increase of the moisture in the air and in the soil, and the slight diminution of the sunlight must all have their effect.

Passing in due course, to the biological conditions originating lakeward and capable of modifying the back strand, certain general suggestions may be worth bringing forward. The line

between back strand and mid-strand is what has previously been termed by the writer a *tension line*—that is, a line between two general groups of plants striving to move in opposite directions. At such a tension line a reciprocal stress is developed, and the plants of the mid-strand strive to enter the back strand while those of the later area in turn attempt to work out upon the former. Wherever a mid-strand bar is sent up into the back strand, there particularly the mid-strand plants insinuate themselves, but even where no favorable physical conditions have arisen to assist, there is a tendency on the part of the lakeward established group to creep in between the meshes of the landward formation. Thus, from this reciprocal biological strain of one formation against the other an irregular boundary zone is developed, and nowhere is the exact line of demarcation altogether clear and distinct. Thus characteristic back strand plants such as *Convolvulus sepium* frequently work out into the extreme mid-strand and with equal adroitness such plants as *Elymus canadensis*, *Artemisia caudata* and *Prunus pumila* creep up upon even the most shaded heights of the back strand.

A peculiar biological influence that modifies back strand, at certain isolated points on Lake of the Woods not connected with the mainland, is the nesting of the gulls and terns with which the lake abounds. By their deposition of guano, and probably too, by their carrying in of seeds, these birds have at various points on island back strand established conditions favorable to the development of vegetation islands that may mark the approximate spot of the rookery long after the birds have deserted it. The contribution of nitrogen to the soil makes it more suitable as a substration for nitrophytes and at such spots an overplus of plants demanding considerable nitrogenous food may be found.

While by no means all the conditions arising lakeward and tending to modify the back strand have been touched upon, enough have been mentioned to show the character of the problems and the discussion may pass on to the conditions arising landward, by which back strand formations may be modified. As in the case of the conditions arising lakeward these may be grouped as physical and biological. The physical conditions are somewhat numerous and depend upon the exposure, contour, and general character of the back country. Back strand upon which there is a drainage from the inland regions behind, differs markedly from that limiting the border

of a uniformly lower area towards which whatever drainage currents there may be will flow. At Sandy beach, although the back strand is a relatively low ridge, yet as one stands upon it he sees landward an apparently interminable low swamp with spruce and larch and intervening reed-bogs and sphagnum bogs. Nowhere near does a continuous rise take place from the back strand to the general country-level. Consequently at the Northwest Angle the back strand forms a levee like ridge, and frequently this ridge is less than fifty yards in diameter. On the one side is the lake and on the other swamps and low lands extending for miles. Such a condition does not favor the constant diversion of moisture to the back strand by higher land behind, and under such conditions the back strand does not form strand pools so abundantly as on such an area as Oak point. Here higher land lies behind the strand, except at the end of the point, and thus a drainage current sets towards the edge of the lake and in the back strand this accumulates in the strand-pools. Again, the greater breadth of the back strand at Oak point as compared with Sandy beach, permits the wind to execute more of an irregular dune-like contour of the surface and this contributes to the formation of pools.

The character of the back-country has further effect in producing physical conditions tending to modify the back strand by its alteration of the direction, intensity or humidity of atmospheric currents and by the nature of substances washed down from it in drainage-water—if such exists A dank, illimitable swamp affects the back strand atmosphere differently by its proximity from a succession of pine-clad hills or ridges of rock covered by crevice plants and mosses and lichens. The first named condition actually prevails at Sandy beach while the second is observed at Oak point.

In general, modifications of the substratum and of the atmospheric conditions, as well, may originate in the region behind the back strand and the temperature, illumination, humidity of the affected region may be correspondingly changed.

Of biological conditions originating landward and tending to modify the back strand, a great deal might be written, for the group is a complex one. In the first place it must be observed that another minor tension line runs at the rear of the back strand similar to the one which runs along its outer edge next to the mid-strand. And just as in the former case, reciprocal influences are set in motion between the adjacent formations so that one falls back or advances while the other moves in the

opposite direction. When the back strand is not cut off from the general back country population by ditches and marshes, there is a marked development of back country types of plants along ridges in the back strand so that just as mid-strand bars are inserted into the back strand from the lakeward side these masses of back country plants are thrust in from the landward side. Hence, a back strand bordered landward by coniferous formations will itself partake of the coniferous character while one bordered by dicotyledonous trees will have rather the deciduous plants as its characteristic inhabitants. Yet even to this apparently universal generalization there are notable exceptions as when a *Quercus* or *Populus* formation maintains itself on the back strand without admixture of *Pinus divaricata* although the general back country formation is consistently *Pinus*. *Picea* and *Abies* forest.

Upon larger islands and upon the main land this back-country influence is especially strong. Upon smaller islands —omitting naturally those which are too small for the full development of strand zones—there is less to be made out in its study. A constant and vigorous struggle for supremacy is maintained by the various plants of the general population and many of these will fight their way down to the back strand, accepting there unusual and unfavorable conditions. Upon the back strand, then, it is common to find stray plants maintaining themselves feebly upon the dark sand and evidently wanderers from the region behind. Thus upon the Oak point back strand one finds small, dwarfed trees of *Pinus strobus* and *Pinus resinosa* and even of the swamp-loving *Picea mariana*, established upon the sand. With these come *Arctostaphylos* and *Comandra*. It follows, too, as a matter of course that back strand, limiting a region of monotonous plant population, will itself receive influences less complex than where it faces a region of diversified population.

Since the influence of aquatic birds was grouped among conditions arising lakeward, it would be appropriate to consider under this topic the influence of land animals. At Lake of the Woods this can hardly be a very important biological influence, but the advent of bears, deer, moose or caribou and especially their habitual visit to certain pools of the back strand must have its influence upon the vegetation. Thus at one pool on the Oak point back strand, frequented, I was told, by deer, stray plants of *Ledum*, *Eriophorum* and *Beckmannia* were noted, probably brought in by the roving animals from some distant swamp.

In concluding this discussion of influences tending to modify the back strand population, it may be said that the successive zones of beach formation—front strand, mid-strand and back strand, show an interesting progression in complexity. The first named is by far the simplest, the last by far the most complex. In the case of front strand, impact of surf places a rigid limit on the types of plants that can develop. For the mid-strand the spray, wind, surf and occasional inundations place a limit, but not so definite a one as for the front strand. For the back strand a limit is placed by the texture and chemical nature of the soil and by the mid-strand border. Otherwise it is free to be tenanted by whatever back country plants may attempt to push in. Thus back strand, of the three zones, is the most complex in its plant population. Since more, and more complex, modifying conditions affect it than affect the mid-strand, or the front strand, it is correspondingly a more diversified area and a larger number of types of back strand need to be examined. The ecological reasons for such a generalization have already been given; it remains to note in order the principal types of back strand formations that have been studied at Lake of the Woods.

I. Gramineous back strand may appear in two principal forms—as meadow-like slopes with strong development of *Agrostis* and *Alopecurus* or as dune-like slopes with *Elymus* and *Calamagrostis* as the characteristic plants, with often a considerable mixture of *Hordeum* and even of *Agropyron*. The representative of the latter genus—*A. tenerum*—according to my observations, less commonly exists upon back strand than do the others. The first variety of the formation indicates a greater percentage of nitrogenous matter mixed with the sandy substratum than does the second. Therefore under the general conditions that form gramineous back strand, the one variety or the other may be regarded as an indication of the humus-content and the differences between two areas of grassy back strand, in this respect, are controlled by the conditions regulating different percentages of nitrogenous material—for example, slow drainage, low elevation giving less sweep to the wind, shade from neighboring objects or contour of surface making accumulation of organic debris more probable. Gramineous back strand often develops just lakeward of a dense tree growth classified as belonging to the back country, but in some cases at Lake of the Woods the grass covered slopes are bare and open. In such cases the ridge is low,

broad, rounded and with slight depressions. Broadly stated gramineous back strand indicates a particular exposure, contour and texture of the substratum, favorable to slow drainage and protected by its gentle elevation and by sheltering vegetation, in some cases, from the strong action of the wind.

II. Mixed herbaceous back strand, is a name which may be applied to the growth of *Artemisia*, *Potentilla*, *Elymus*, *Epilobium*, *Onagra*, *Polygonum*, *Ranunculus* and other herbaceous genera that often characterizes openings in the shrub and sometimes is developed in characteristic form over considerable areas to the exclusion of other kinds of plants. As in the case of gramineous back strand two varieties may be distinguished, an *Artemisia-Elymus* type in which humus-content of the soil is relatively less and a *Ranunculus—Onagra* type in which the humus-content is relatively greater. In general, when extended over more than very limited areas this type of back strand indicates a considerable degree of moisture in the soil and the more varied the species of herbaceous plants that inhabit it, the more certainly will the soil be found of such texture, contour and exposure that a higher degree of moisture can be maintained near the surface than in the case of many of the wooded back strand tracts.

III. Coniferous, shrubby back strand. Of the five types of shrubby back strand to be described, this one in particular is characterized by the predominance of either *Juniperus communis* or *Taxus minor* in the formation. Both back strands commonly indicates a response to biological influences from the inland vegetation. Thus upon back strand with heavy rock ledges rising shoreward a development of *Juniperus* may be expected, while upon back strand bounded shoreward by dense *Pinus* or *Betula* woods with strong development of humus it is often to be observed that *Taxus* will creep out upon the sand formation. Such coniferous shrubby back strands are generally sheltered from strong wind currents and indicate sterility of soil and infrequent inundations of surf.

IV. *Populus* shrubby back strand. This very common type indicates the prevalence of strong wind currents and characterizes some of the most exposed points and bars on the lake. It is developed usually on low lying sand spits and indicates also a sterility of the soil with often, I am inclined to believe, relatively strong spray saturation of the atmosphere. All the common northern species of *Populus*, *P. deltoidea*, *P. tremuloides* and *P. balsamifera*, contribute to the formation, but the two lat-

ter are the more abundant. Yet dwarfed *P. deltoidea* shrubs are characteristic of much of the back strand along the southern shore of the Grand Traverse. It is not often inundated.

V. *Salix* shrubby back strand. This type characterizes low, commonly inundated, rather strongly nitrogenous back strand, and is found in conjunction with *Salix* mid-strand. It does not indicate strong wind-currents and is commoner in sheltered bays or behind islands than upon the shores that face wide expanses of water. Various species of *Salix* are represented of which doubtless *Salix lucida* and *Salix discolor* are the most abundant.

VI. Rosaceous shrubby back strand. For miles on the Grand Traverse shore this type of back strand is abundantly developed. The characteristic plants are *Rosa blanda* and *Rosa woodsii* with *Cerasus pennsylvanica*, *Cerasus virginiana* and *Amelanchier canadensis*. In no case do the plants attain a considerable size and often a shrubby formation no higher than one's head is maintained for hundreds of yards. The favorable conditions for this type seem to be high banks, exposure to strong winds, absence of occasional inundations and a fairly high percentage of nitrogenous substances in the soil. Yet sometimes a rosaceous formation is found growing upon what appears to be almost pure sand, and similar formations are found upon the dunes. In general the establishment is more characteristic of slopes than of summits or hollows and indicates a sensitiveness to drainage conditions and the movement of soil waters. At the season of blooming for the genus *Rosa*, such a back strand makes a bank of pink color behind the yellow *Elymus* and *Artemisia* dotted mid-strand that is noticeable from the decks of steamers far from shore.

VII. Mixed shrubby back strand. This type is in point of fact probably separable into minor varieties such as *Vitis* back strand, *Rhus* back strand and others, but nowhere on Lake of the Woods were characteristic groups developed strongly enough, except from the shrubs before mentioned, to justify such a nomenclature. The mixed shrubby back strand indicates either light or fertile soil, strong wind-currents and an irregularity of surface contour with corresponding differences in percentage of soil water between adjacent very limited areas. In such a mixed shrubby back strand *Quercus* scrub and *Fraxinus* with small, dwarfed individuals of *Ulmus* are not uncommon. The complexity in number of species is directly connected with the surface contour.

VIII. Coniferous arboreal back strand. The principal plant of this formation is *Pinus divaricata*, the "Jack pine" of the Minnesota loggers. Yet it is only under certain favorable conditions that formations of this plant arise upon the sandy ridges of the Lake of the Woods back strand. It appears from my observations that these conditions are relatively deep sterility of the soil, slight exposure to winds, and a low, irregular surface on which, however, pools are not abundantly formed. The clear sand, which is so constantly seen about the roots of the pines, does not appear to become much richer in nitrogenous content even when one digs below the surface. A slight contrast therefore arises between this type and the Rosaceous, shrubby back strand, for, in the case of the latter, usually the superficial layers of soil are more sterile than those deeper down.

IX. *Populus* arboreal back strand. Favorable areas for the development of this formation appear to be low, fairly nitrogenous soil, with regular surface-contour and infrequent inundations. Such back strands are sheltered from strong winds if they are to be perfectly developed, otherwise *Populus* shrub is formed instead. From the more sheltered localities occupied by such back strand formations, and from the wind-breaking force of the trees it becomes possible for the sand to lie quietly and for dead leaves and other plant products to build up humus. Hence the greater fertility of the soil than where a *Populus* shrub is established. In the differences which arise between *Populus* shrub and *Populus* tree formations I presume the relative exposure to wind currents is of no slight importance. It will be observed that, once established, a tree formation acts as a wind-break, and thus accentuates the conditions under which it is supposed to develop most readily in the first place.

X. *Salix* arboreal back strand. In this formation, which is developed upon certain special areas, there is an evident adaptation to the following conditions: a low-lying, moist, sometimes inundated, shore, considerable nitrogenous material, absence of surf or heavy winds, and the absence of coniferous formations in the back country reaching the back strand. A *Salix* back strand formation does not flourish at Lake of the Woods when backed by coniferous vegetation, for in such a case the tree-types of its locality are more probably tamarack or spruce. But when backed by meadows, or by hardwood timber such as *Betula* or *Populus*, the *Salix* arboreal back strand may maintain itself in great perfection. A fine example of it

is shown (*Plate LXX*), where the back country is shrub and meadow. In such *Salix* back strand *S. nigra* is a conspicuous species together with *S. amygdaloides*, but the former is more abundant.

XI. *Quercus* arboreal back strand. The prevalence of small trees of *Quercus macrocarpa* is sometimes so considerable upon certain shores that one is justified in discussing the group as a distinct back strand formation. I find it at Lake of the Woods characteristic of rather low, rounded and fertile shores. Wind exposure if not too great seems not an unfavorable condition. Sometimes an irregular contour of the shore may be maintained without prejudice to the *Quercus* formation, but in such cases the mixed arboreal type is more likely to be developed.

XII. Mixed arboreal back strand. When the surface contour is irregular, the soil fairly fertile, the shore not too low, and the wind activity not too pronounced a mixed forest may develop. In all such cases it is difficult to delimit the back strand from the general back country vegetation and such mixed arboreal back strand indicates slight topographic specialization of the back strand ridge. Upon low shores, sterile shores, regular shores, inundated shores, shores exposed to occasional surf and spray, this type to of formation seems not to develop readily.

This brief discussion of the different back strand formations which are on the whole most easily distinguished as such, for purposes of description, at Lake of the Woods, may be terminated at this point with a recapitulation of the conditions under which development seems ordinarily to progress.

1. Gramineous back strand: Slopes, low elevation, rounded contour, slight exposure to wind.

2. Mixed herbaceous back strand: Soil with power of retaining moisture near the surface. Considerable humus-content.

3. Coniferous shrubby back strand: Absence of inundations, shelter from winds, sterile soil and coniferous back country neighboring formations.

4. *Populus* shrubby back strand: Low sterile soils, strong wind currents; spray, infrequent inundations.

5. *Salix* shrubby back strand: Low, inundated, nitrogenous soil, slight wind currents.

6. Rosaceous shrubby back strand: Higher shores, stronger winds, absence of inundations, fairly high humus-content of the soil.

7. Mixed shrubby back strand: Irregularity of surface contour, strong wind currents, differences in soil fertility between adjacent limited areas.

8. Coniferous arboreal back strand: Low, dry, irregular surface, deep sterility of soil, slight wind currents.

9. *Populus* arboreal back strand: Low, nitrogenous, not inundated, regular contoured, sheltered areas.

10. *Salix* arboreal back strand: Low, moist, nitrogenous, inundated, sheltered shores without coniferous formations immediately behind.

11. *Quercus* arboreal back strand: Low, rounded, nitrogenous, wind swept shores of regular contour.

12. Mixed arboreal back strand: Irregular fertile shores not sharply distinguished from the back country by definite topographical outlines.

While the discussion of the back strand formations has been suggestive rather than exhaustive enough has been brought forward to indicate the strong dependence of the vegetation-groups upon the environmental conditions. Indeed a catalogue of the individual plants of a given area of definite size, with information of the habit of the plant individuals, whether they were shrubs or trees, would almost enable one to plat the topography of the area, provided it was selected within some such field of previous observation as in this instance, Lake of the Woods.

Strand-pools. There are three types of strand-pools at Lake of the Woods. They are:

1. Pools of the front strand.
2. Pools of the mid-strand.
3. Pools of the back strand.

These are of different methods of formation, of different duration and characterized by plant populations which are to some extent distinctive.

I. Pools of the front strand have already been discussed under the general caption of *Front strand.* They are formed solely by the action of surf and are of short duration. Their plant population consists therefore, only of lowly algae that are brought into them by the accession of water from the lake and eventually each of these pools will evaporate and during the next heavy surf, new ones will be formed, to disappear in their turn. In such pools the principal inhabitants at Lake of the Woods are Cyanophyceae of the genera *Aphanizomenon*, *Anabaena*, *Nostoc*, *Oscillatoria* and *Lyngbya*.

II. Pools of the mid-strand. These are formed by the waters of the lake thrown back in the heavy surf, or produced in the mid-strand area by the construction of bars off shore. Such pools may remain for several years, as long, indeed, as the bars which bound them are permitted to exist. By the slope of the beach such pools also receive accessions of water from the rains and drainage channels are formed which bring water to them from portions of the strand some distance away. Water falling upon the lakeward slope of the back strand is also brought into such pools. They are therefore formed by surf and by rains. Owing to their real impermanence they do not usually become tenanted by many species nor by those of most robust growth. A list of the main plants in a mid-strand pool at Oak point is appended.

Mid-strand pool formation at Oak point.

Sagittaria graminea.
—— latifolia.
—— rigida.
Eleocharis palustris.
Eleocharis tenuis.
Juncus articulatus.
Lemna minor.

These plants were distributed about the shallow pool, and towards the center the water was open. None of them were of great age, as was determined by an examination of the rhizomes, and the scanty development of species was clearly connected with the shallowness of the water and the short duration of the pool, as a feature in the topography.

III. Pools of the back strand. These being for the most part outside the region of surf influence are rather rain-water sink-holes in the back strand, than surf-fed or surf-formed pools, like the two first mentioned. They are dependent upon the contour of the back strand for their depth and size, and are commonly permanent features of the topography. Consequently they are populated by a greater variety of species and by plants of more robust growth. A list of varieties found in a back strand pool at Oak point is furnished.

Back strand pool formation at Oak point.

Typha latifolia.
Potamogeton foliosus.
Potamogeton heterophyllus.
—— perfoliatus var. richardsonii.
Sagittaria graminea.
—— latifolia.
—— rigida.
Eleocharis palustris.
—— tenuis.
Scirpus cyperinus.
—— lacustris.
Lemna minor.
Juncus articulatus.
Iris versicolor.
Roripa palustris.
Spiraea salicifolia.
Utricularia vulgaris.

Such pools of the back strand are commonly surrounded by plants of hydrophytic aptitudes, such as *Cyperus*, *Betula*, *Im-*

patiens, Lysimachia, Naumburghia, Lycopus, Mentha, Scutellaria, Stachys, Vleckia, Plantago, and others, so that both by their aquatic population, and by the forms lining their shores they become a distinct feature. The limnetic formations may, upon a small scale, reproduce the zonal formations of the larger lake, but depend rather upon variety of humus than upon other conditions.

In general the population of a strand pool depends upon its depth, its size, and its duration. In large strand pools *Scirpus* and *Phragmites* formations with *Castalia,* and even *Chara,* may appear. Such pools occupy centers of drainage, are of complex population within, and are surrounded by several zones of limnetic plants.

DUNES.

Dunes are not abundantly developed at Lake of the Woods, but one very characteristic series has been formed near the mouth of the Rainy river. In low water these dunes are joined by spits and necks of sand, but in ordinary stages of the lake they are separated as a chain of sand-hill islands. Beach formations are abundantly developed, but more especially on the shoreward side, while the side exposed to the winds and surf of the Traverse shows narrower and scanty strand-areas. This chain of islands is known as the *Isle aux Sables,* or the *Sand Hills.* In this connection it will not be necessary to consider the strand plants but rather those peculiar distributions and groupings which characterize the dune as distinguished from the beach. A list of species observed on a limited area of the Isle aux Sables is here presented.

Dune formation on Isle aux Sables.

Juniperus communis.
Juniperus sabina.
Pinus divaricata.
—— resinosa.
Agrostis hiemalis.
Calamagrostis canadensis.
Elymus canadensis.
Carex filiformis.
—— scoparia.
Eleocharis palustris.
—— tenuis.
Juncus canadensis.
—— tenuis.
Populus tremuloides.
Salix discolor.
Betula glandulosa.
Quercus macrocarpa.
Celtis occidentalis.
Allionia nyctaginea.
Castalia odorata.
Cerasus pennsylvanica.
Potentilla arguta.
Prunus pumila.
Rubus strigosus.
Sorbus sambucifolia.
Spiraea salicifolia.
Lathyrus maritimus.
Rhus radicans.
Hypericum ellipticum.
Hudsonia tomentosa.
Onagra biennis.
Cornus sericea.
Fraxinus americana.
Sambucus pubens.
Campanula rotundifolia.
Artemisia canadensis.
—— caudata.
Solidago juncea.

In many respects this is a remarkable group of plants. The presence of *Juniperus sabina*, *Hudsonia tomentosa*, *Campanula rotundifolia* and the distribution also of some of the grasses suggest the aspect of rocky shores where, on high barren ledges, these plants are characteristic. The most important generalization that is to be derived from a study of these dunes as a whole, is that their population resembles that of rock shores rather than of beaches. The meaning of this appears to be that texture of the soil is less important here in determining the types of vegetation that shall become established, than are the other factors—e. g. sterility, elevation, exposure to wind, withdrawal from spray and diminution of moisture. Indeed, except for its texture, the dune is chemically and topographically similar to the rounded quartzyte and gneissic masses with which the whole region abounds. I take it that the prevalence upon dunes of *Juniperus sabina*, *Hudsonia tomentosa*, *Campanula rotundifolia* and the rest indicates an essential ecologic similarity between dunes and rock masses, and the vegetation of the dune which at first sight would naturally be connected with beach vegetation must really be regarded as of lithophytic rather than as of ordinary psammophytic, limnetic types.

It is possible instructively to classify the dune formations as developed upon dune slopes, dune summits and in dune pools. These three areas may be noted briefly in their sequence.

Dune slopes. Owing to the shifting, loose, sterile condition of the substratum, only a small group of plants characterizes this area. *Plate LXXIII* gives a view of an altogether typical slope on Isle aux Sables. The vegetation of the foreground shows *Prunus pumila*, *Populus tremuloides* and *Juniperus communis* as the dominant species, while farther back *Artemisia* and *Elymus* may be discerned and to the right a dune summit bearing dwarfed trees of *Celtis* and *Cerasus*. *Prunus pumila* a pronounced psammophyte finds such slopes a congenial home, and the species is developed in such areas quite as abundantly as upon the strand. *Juniperus communis*, rather rare upon beach areas except where it enters the back strand from a coniferous formation inland, is abundant, upon the dune slopes, but not more so than its congener *J. sabina*, an omnipresent crevice plant over all the rocky islands of the region. It must be noted that the station of a shrub like *Juniperus* upon a dune produces around its roots somewhat of the conditions of a crevice. The prostrate habit enables it to hold organic substances, and the

sand around its base will contain more nitrogenous material than is ordinary on the general dune slope.

By the shifting of the sand, propagation is rendered difficult, the number of species is cut down so that dune slopes come to be monotonous beds of *Prunus*, *Juniperus*, *Elymus* and *Artemisia*, with occasional dwarfed shrubs of *Populus*, or even of *Sambucus*. By the constant shifting about of the sand, the soil is turned over and oxidized, and this process is unfavorable both for the storage of moisture near the surface, and for the development of a general nitrogenous richness that would favor the growth of herbs. It is only on the dune summits, and there sparingly, that such plants as need humus-content in more marked quantities, can very well establish themselves.

The characters of the dune slope, then, are these: sterility, exposure to wind, low moisture-content, low temperature, constant oxidation of organic waste—in short much the same characters that one would discover in the study of a ledge of light colored quartzyte. The vegetation, by its types, its monotony, its dwarfed and prostrate habit, and its extreme looseness of aggregation responds to these conditions in much the same way that it does when establishing itself upon a rock surface.

Dune summits. The surface of the dunes is generally altogether irregular, a succession of slopes, hummocks and hollows. The tops of the hummocks are commonly tenanted by a distinctive group of small trees or shrubs with a limited interstitial vegetation somewhat like that of back strand areas along shore. Such a dune summit is shown in *Plate LXXIV*, and a somewhat zonal arrangement of plants may be observed. Surrounding the clump of shrubs that occupies the summit is a growth of *Elymus*, *Artemisia* and *Agrostis* with *Juniperus* seen on the right. The common trees of these dune summits on Isle aux Sables are *Quercus*, *Fraxinus*, *Celtis*, *Cerasus* and *Populus*, together with numerous individuals of *Sorbus sambucifolia*. Mingled with the dwarfed trees are shrubs of *Rubus*, *Rhus*, *Spiraea*—a plant with great catholicity of habitat—and *Betula*. Depending somewhat upon the size and age of the summit formation, there are added low herbs including *Vagnera*, *Hypericum*, *Potentilla*, *Onagra*, and others, but the variety is always small, and dune summits, like dune slopes, show a great monotony of specific types.

The conditions at the dune summit differ from those of the slopes in one or two important ways. The formation is much

more closely aggregated, and hence gives shade, raising the temperature of the soil at night and assisting in the harboring of soil water. Thus the surface becomes moist enough, especially near the base of the largest trees of the area, which act as drains for the rain drops, for the establishment of such plants as *Vagnera* and *Onagra* The soil is less oxidized, not being exposed to such frequent shiftings by the wind, and the humus-content rises. Directly or indirectly, all of these conditions co-operate for the development of a more stable substratum, and one upon which a greater variety of plants can dispose themselves. Therefore, in number of species, the dune summits quite surpass the dune slopes or even the dune hollows. These latter, unless they become sinks for rainwater, do not show any characters particularly different from those of the dune slopes.

Dune pools. While the dune pool resembles the pools of the back strand previously described in being formed from rain water drained in from the slopes which surround it, it is rather more nearly related to the pools of the mid-strand in its scanty vegetation and in its failure, in almost every case, to be surrounded by zones of plants developed upon moist or mixed humus, such as the *Vleckia* and *Scutellaria* formations described for the pools on the back strand of Oak point. The dune pools, too, from the shifting of the sand that continually takes place are never deep and hence their vegetation is limited by this condition. In *Plate LXXV* a characteristic dune pool is shown on Isle aux Sables surrounded by *Juniperus sabina*, *Hudsonia tomentosa*, *Prunus pumila* and *Artemisia caudata*. In the back ground is seen a low dune summit with *Celtis* trees and one or two taller plants of *Quercus macrocarpa*. The vegetation of this dune pool consisted exclusively of *Eleocharis* and *Juncus*—a very common grouping in such shallow sink holes on these dunes. In one deeper hole a plant of *Castalia*, doubtless sown by birds, was found growing but such a plant is exceptional in these pools, and even *Sagittaria* so abundant in the region is more often absent from the pools of the dunes.

The shifting of the sand is probably the principal occasion for such limited pool formations, because the pools when formed under natural conditions of the drainage are quickly blown full of sand and can not maintain the depth necessary for the establishment of a more varied aquatic population. Thus the exposure to wind of the dune as a whole indirectly limits the flora of the dune pool.

The influence of vegetation in fixing the sand and gradually building up the dune need not receive particular treatment here. It is well known that by the establishment of a few grasses or *Artemisias* at some spot a hill may be gradually formed around them, their roots uniting the particles of sand and eventually binding the whole mass together in a mound. Over this the grasses continue to grow, the mound growing with them. When large dunes are formed every thing may be upon a large scale. For example, in the well known region about Lake Michigan, in northern Indiana, more extensive slopes, summits and pools are formed and here an entirely different series of problems in ecologic distribution must be considered in so far as the sand encroaches upon areas previously covered with vegetation of another physiognomic group. The types of the large dune pools of Indiana with their characteristic limnetic zones of *Solidago* were not observed at Lake of the Woods. Such zones depend upon a greater general moisture less exposure to the wind, owing to surrounding trees of pre-dunal development, and a general higher temperature. *Solidago juncea* found sparingly on the Isle aux Sables seemed rather a plant of the summits than of the pool borders. At Lake of the Woods there is no evidence that the Isle aux Sables is tenanted by both dunal and pre dunal types of plants. On the contrary the shoreward side of the dunes seems rather to have become modified from its original type, permitting at present strand formations to develop. A very clear, sharp delimitation of back strand and mid-strand may be seen in a view of this shoreward aspect of the Isle aux Sables in *Plate LXXII*. The mid-strand is of a mixed *Salix* and *Cornus* variety and the back strand is of the shrubby *Populus* type.

MORASSES.

This form of shore vegetation has been classified as *attached* and *detached*, but really some of the apparently fixed morass should be placed in the second group rather than in the first. This is true of what is here termed anchored bog. For in this formation a juxtaposition of plants may arise quite the reverse of that in the ordinary attached morass. Such is the case when a bog floating from one shore to another becomes attached to the bottom with its originally lakeward aspect now turned shoreward. Since the peculiarity of plant distribution in such cases is conditioned upon the formation having moved

from its original place of development, it seems more reasonable to include the anchored bogs under the second category.

Morasses are generally either peaty in structure or formed of grasses and sedges. The peat morass, so far as my observations go, is not developed at Lake of the Woods as an along shore formation though it occurs thus situated in some of the smaller ponds of the back-country. I therefore judge that in all probability such peat marginal formations will be found in some of the secluded bays of the main lake. The peat shore population as I first showed in a paper published in 1894[8] may under certain special conditions give rise to the singular formations named "Sphagnum atolls." None of these have been seen in the Lake of the Woods region, although they may possibly occur, and have readily escaped observation. Where morass is found as a shore formation on this lake it is generally of the gramineous or cyperaceous variety.

Morass does not face exposed sheets of water, but is confined to the narrower bays and coves where surf can not easily be formed, for there is little wind, and upon shelving banks rather than upon precipitous. As a consequence I have not found the formation facing either the Grand Traverse or the Little Traverse, but in such regions of the lake as the west shore of Flag island, the east shore of Oak point and the sinuosities of MacPherson's bay it is a conspicuous shore-type, and may be classified generally into the two main groups of attached morass and detached morass as indicated above. Of attached morass two types are recognized, wet and dry. The former is loose and spongy and will not bear one's weight upon it, the second is firm and in its different varieties will always support one walking upon it. The different types may be examined *seriatim*.

Wet morass. An example of this in Echo bay, near Rat Portage, is shown in *Plate LXXVI.* Here it consists of two well marked zones, an outer one of *Scirpus* and an inner one of *Salix.* But these are by no means always the characteristic types. As varieties of wet morass the following may be named.

I. Gramineous morass. The characteristic plants are grasses and the basis of the formation originates from the interlocked, tangled rhizomes and roots of these plants. In some cases *Phragmites* is the principal plant, in others *Zizania*, in still others *Panicularia*, Of the three kinds that formed by

8. **MacMillan.** On the occurrence of Sphagnum Atolls in Minnesota. Minn. Bot Stud. **1:** 2-13. 1894.

Phragmites is commonly the firmest, and that formed by *Panicularia* the loosest in texture.

II. Cyperaceous morass. Usually the dominant plants are members of the genus *Scirpus* and with these as basis a little group of plants is aggregated which may eventually give foothold to shrubby and even to arboreal species of other families.

III. *Sagittaria* morass. Beds of *Sagittaria* are sometimes formed very abundantly and produce a kind of wet morass especially when such plants as *Sagittaria cuneata*, found in some of the bays are the dominant species. *Sagittaria*, though is perhaps as commonly a component of the dry morass formations.

IV. *Polygonum* morass. Of this the dominant species is *Polygonum emersum* and off some rather deeper, rocky shores, such a type of attached bog is formed that one can attribute it altogether to the activity of growth of this plant.

V. *Salix* morass. Here the dominant species is *Salix myrtilloides* usually developed not as an independent but as a subsidiary bog plant associated with *Sphagnum* formations. Yet at Lake of the Woods upon some shores, masses of this willow are developed to such an extent that finally a sufficient amount of humus is collected around their roots to afford a foothold for the little group of sedges and grasses that accompany the formation.

VI. *Menyanthes* morass. At one or two points the morass is evidently built up and perpetuated largely through the growth of *Menyanthes trifoliata*.

VII. *Utricularia* morass. This is a loose type and is not often developed. At a shore near Northwest Angle inlet, however, the plants of *Utricularia vulgaris* were so abundant that they had built up a morassic shore some seven feet in width near a ledge of rock, and in water six feet in depth.

While there are other types besides these, in all probability, the ones named are the characteristic forms at this lake. There should be added, perhaps, an eighth group—mixed morass—to include those morassic shore formations in which the dominant plant would not be clearly distinguished in the group established. However, usually a little care will enable one to decide upon the plant most responsible for the formation.

All of these morassic formations characterize quiet shores Most of them indicate a shelving gradually deepening lake-margin, but one or two may be developed off abrupt edges, as for

example the *Polygonum* and *Utricularia* types. When any one of the types has become established the constant addition of decaying organic substance builds up what has been termed wet humus and gradually a spongy coherent substratum is elaborated and upon this numbers of plants of hydrophytic tendencies will find a home. Numerous small *Carices* and *Ranunculi*, *Caryophyllaceae* and *Labiatae* establish themselves, together with grasses, and the bog shows a transition to the dry type. It should be noted that the rhizomes and roots of the plants are the active agents in binding together the humus in some cases, while in others the floating areas of the plants, as in the *Panicularia* and *Utricularia* varieties, play an important part.

Dry morass. This name may be applied to those morassic shores on which the accumulation of humus has reached a point where every year it remains for the most of the time fairly above the average lake level. In the piling up of the humus in this fashion a number of causes co-operate. Among the interesting influences under which wet morassic areas may become dry should be mentioned the following:

1. The influence of ice-floes. These, crowding against a wet morassic shore in the spring sometimes pile up the humus in such fashion that it is condensed and elevated into a permanent ridge. In this condition its plant population changes.

2. The influence of outgrowing roots of shoreward established plants. By the pushing in of heavy roots from trees, usually willows, birches or tamaracks, and in some cases spruces, the wet morassic soil is lifted and gradually brought up where it is for the most part out of reach of inundation.

3. The lifting force of gases of decomposition developed in the humus itself. By this means a general elevation of the humus mass is brought about in some instances and the whole substratum is, as it were, *leavened* and by the growth of rootlets and further deposition of humus the spaces thus formed become filled first with water, then with soil components.

These are in addition to, and an accentuation of the steadily progressing increase in bulk of the wet morass due to the formation of generation after generation of leaves, roots and stems by its plant population. Thus, beginning in a variety of ways,—as a bed of *Utricularia*, a growth of reeds, a mat of sedges or a tangle of willows—the wet humus may be gradually changed to dry and in this process its plant-population slowly but definitely changes.

Dry morassic shores may be divided into herb bearing, shrub-bearing and tree-bearing morass as the process of drying is continued.

I. Herb-bearing dry mosses. Of this a number of types should be defined if one wishes to cover the whole ground. At Lake of the Woods the following have been particularly observed:

a. *Cyperus* dry morass. The dominant plants are various members of the genus *Cyperus*, *Dulichium* or *Eleocharis* and sometimes of *Carex*.

b. *Veronica* dry morass. The dominant plants are members of the genus *Veronica*.

c. *Labiate* dry morass. The dominant plants are mints such as *Scutellaria*, *Mentha*, *Vleckia* and *Lycopus*.

d. *Plantago* dry morass. The dominant plant is *Plantago major* or *Plantago rugelii*.

e. *Caltha* dry morass. The dominant plant is *Caltha palustris*.

Besides these a number of other sub-types might be described, but those given are certainly the most prominent and may serve as examples.

II. Shrub-bearing dry morass. Of this there are really but three clearly defined sub-types in the region, so far as my observations have gone:

a. *Salix* dry morass. The dominant plants are members of the genus *Salix*. Among them *Salix lucida* and *Salix myrtilloides* are conspicuous.

b. *Cornus* dry morass. The dominant species are *Cornus baileyi* and *Cornus sericea*.

c. *Spiraea* dry morass. The dominant plant is *Spiraea salicifolia*.

III. Tree-bearing dry morass. Here again three sharply marked sub-types may be observed.

a. *Larix* dry morass. The dominant species is *Larix laricina*, the tamarack.

b. *Picea* dry morass. The dominant species is *Picea mariana*, the spruce.

c. *Betula* dry morass. The dominant species is *Betula papyrifera*, the birch.

As a matter of course none of these dry morass formations always exists in a pure state, but very often mixtures and transitions between one type and another or between dry morass and wet morass types will be established over a given

shore area. Very beautiful exhibits of zonal distribution are often afforded upon shelving shores provided with morassic formations. Ten or twelve distinct zones of plants will be developed as the moisture content of the soil diminishes from the edge of the water, inland. *Plate LXXVI* shows four of these zones; a *Scirpus* zone nearest the water edge, a *Salix* zone farther inland, a *Betula* zone behind this and finally a *Larix* zone backed by trees of *Pinus strobus*, the latter not belonging, however, in this case, to the true shore group.

Floating bog. Coming next to the consideration of detached morass it should be observed that such does not develop under quite the same conditions as does the permanently attached morass. The following are favorable conditions for the formation of detached morass.

1. A smooth surfaced bottom without the numerous crevices or irregularities that would assist roots to hold fast and thus keep the morass in place.

2. More exposed situations, at the heads of broad or extended bays, where higher winds can arise and hence more surf energy would be developed, tending to separate the morass from the shore behind.

3. A higher percentage of floating plants in the original morassic composition, as for example, *Paniculariàs*, *Utricularias*, *Potamogetons*, *Lemnas* and others in which a considerable portion of the plant body, if not the whole, is natant.

4. More precipitous shores where the detachment is sharper and easier than if the bottom shelves gradually.

5. Weak places in the morassic texture where, owing to some zone of detachable plants, the whole lakeward mass can be removed from the shoreward portion. Such a line may be be called the *scission line* of the formation.

Under a variety of conditions, especially when they co-operate, morassic areas may be detached and carried into deeper waters. In some of the lakes of Minnesota these floating bogs are very prominent features and constitute the so-called "floating islands." At Lake of the Woods they do not seem to be abundant. The best specimens observed are in Northwest Angle bay, Moose bay and Four Mile bay behind Oak point. As developed, the floating bog comes to have some characters peculiarly its own, due to the moving about in the water and the removal from the particular point of attachment. The peculiarities of the floating bog are these:

1. A floating bog comes to have a redistribution of its component plants so that if it has been long separated from the shore where it was formed it no longer shows the longitudinal vegetation-striae of the old zonal morassic shore but develops a zonal grouping of its own. The peripheral areas are therefore specialized from the central and a group of plants established at the water's edge, able to bear the lapping of the waves and enjoying the higher illumination, may be distinguished. At the center of the island shrubs or even small trees may become established and the whole bog, if it were not for the next condition to be observed would be characterized by a series of zones very plainly marked, but not the old zones of the original shore.

2, A floating bog drifting about in a bay from one shore to the other, touching at different points and frequently exposed to the strong winds in the middle of the bay, while in transit from bank to bank, becomes a resting place for numerous varieties of light seeds. Furthermore, while temporarily situated at one spot or another on the shore, it is, to some extent, colonized by the plants of that region and thus from both conditions its number of species of established plants tends to rise. Hence, floating bogs of long standing are scenes of very sharp struggle for existence among a considerable number of alien plants. This has a tendency to obscure both the original and the secondary zonal distribution and to a marked degree the floating bog will partake of an azonal character in consequence.

3. The undulating movement communicated to the bog when exposed to wave action loosens somewhat its tangled network of roots and decayed organic substance so that the texture of the soil is modified from that of the general type of attached morass to which it originally belonged. This change in texture brings about a slight change in plant population. Hence floating bogs are usually rich in *Sparganiaceae*, *Typhaceae* and *Carices* which develop under such conditions with considerable vigor.

4. The presence of the lake water underneath every part of the formation keeps it cool and moist beyond what is possible for attached morass. This again has its modifying influence upon the plant population.

These mechanical, biological and other conditions are quite sufficient to give to the floating bog a population distinctively its own. While belonging to the main subdivision of shores to which the name morass is given, it does not, especially if its

floating habit has extended over several seasons, conform either in kinds of plants or in grouping altogether to the attached types.

Anchored bog. It often happens that after floating for a season or two or even for a number of years, a bog is finally carried into some angle or cove from which it does not readily escape and after a time, if the bottom and shore are favorable, it may become anchored. This anchoring arises from the growth into the bottom soil, or into the shore, of roots and rhizomes from the bog group or by the growth into the bog of organs from the shore group or, more commonly, by both processes going on together. When thus anchored, the bog is now subjected to the influences of the new environment and its population becomes modified in consequence. The influences which affect it are both physical and biological. If anchored in some area of strong illumination it develops differently from what it might if the resting place had been one of deep shadow. If anchored off a shore populated with *Coniferae* the bog population will change along different lines from those that might have been established had the shore vegetation been of deciduous trees or of herbs. If the shore upon which it has been carried is similar to that upon which the anchored bog originally developed, the line of changes will not be similar to those which would have taken place if the landing had been made upon a totally different type of shore.

The combination and redistribution of plants which arises in an anchored bog may tend either to accentuate a zonal distribution already established in the bog or to obliterate it. More commonly the latter happens and the floating bog, unless it has come to anchor in its original position upon a shore similar to its shore of origin, will very soon lose all traces of its old zonal aspect. It may happen that the shore is similar, but the lakeward side of the bog is now turned landward, while the originally landward side is turned lakeward. In such a case the original zonal distribution is rapidly converted into azonal and only much later will a new zonal distribution arise.

Again, if the bog comes to rest in a state that can be described only as azonal the influence of the anchorage may be favorable to the continuance of this azonal condition—and this is usually the case—or it may tend to convert it into zonal. Even here, however, the question whether the new position of the bog restores or reverses its original position must come

into the enquiry. I have seen zonal anchored bogs caught in coves surrounded with *Populus* trees and by the juxtaposition the bog was quickly covered with *Populus* seedlings to the obliteration of its zonal character. Again other bogs, quite azonal from their long separation from the shore of origin, coming into a small bay with morassic shore within a couple of seasons showed the distribution in zonal lines already well begun.

In general, concerning floating or anchored bogs, it might be supposed that they could belong to any one of the types of wet morass described above. But practically, so far as has been observed, they are always either gramineous or cyperaceous. Except in rare instances, the *Panicularia* type alone can not develop into floating bog for it is too loosely woven, and the waves soon break it up. The same is true of *Utricularia* morass alone. Nor do the *Polygonum*, nor the *Salix*, nor the *Spiraea* morasses have the separability, the texture, the coherency and the pliability necessary for floating bog construction. In a word, then, these interesting formations begin as morasses of sedges or grasses, but contain also numerous other species of plants. On the whole, *Sparganium* seems to be one of the most characteristic genera of the floating bogs, although *Hippuris* and *Equisetum*, with *Typha*, *Carex*, and *Epilobium*, are very constant components. In no case at Lake of the Woods have any *Ericaceae* been observed on these formations, although *Ledum* and *Andromeda* are not infrequent denizens of floating islands in central Minnesota.

SURF-BARRIERS.

The surf-barrier formations are such as can maintain themselves off shore where the surf has play, therefore they must be able to withstand the occasional or perhaps frequent shock of "white-caps" breaking over or against them. Naturally some shores are exposed to so strong surf that no cumaphyte can live under the impact. This is the case at Oak point, where the breakers from the Grand Traverse strike the shore fairly and come up over the shelving bottom with great vigor. But near less exposed beaches, and off many rocky shores, the waves are not so heavy, and many of the surf-dwelling plants can find a foot-hold.

The general character of cumaphyteo are necessarily such that impact of the waves does not injure or displace them. They are all, therefore, rooted strongly at the bottom, in

humus or drift, but frequently also in crevices submerged below the surface. Floating vegetation, such as *Lemna* or *Riccia*, does not form part of the surf-barriers, nor do plants with large leaves offering resistance to the waves, such as *Castalia*, *Nymphaea* or *Potamogeton natans*, although even these can maintain themselves in pretty rough water. Again vegetation with large floating areas and slender attachments to the soil, which may even ordinarily become disconnected, as in the *Lentibulariaceae*, do not form surf-barriers, for they are too easily uprooted and carried on the shore. The conditions of vegetation, then, result in the selection of a few species of peculiar type for this special habitat.

At Lake of the Woods, five genera of plants seem able to maintain themselves in regions exposed to long continued or intermittent surf. These are *Scirpus*, *Phragmites*, *Polygonum*, *Spiraea*, and *Salix*. Surf-barriers, also of *Equisetum limosum* doubtless exist in the region, having been observed in the Rainy lake country and in central northern Minnesota. None were seen at Lake of the Woods. Of these surf-barrier plants some seem able to withstand strong and long continued surf while others select less exposed shores and are to be looked for rather on the windward side of islands or points and in coves and bays. Hence the classification that has been proposed seem justifiable and the five types may be discussed briefly in their order.

Barriers in strong surf. Of these I find only two types as follows:

I. *Scirpus* barrier. The formation is composed of plants of *Scirpus lacustris* rooted in drift or humus soil and may exist in regions as exposed to surf as any that can afford a foothold for higher plants. Parenthetically, it may be noticed that lichen-formations on surf-washed ledges cannot be regarded as surf-barriers, although certainly they are a type of cumaphytic vegetation. The peculiar structure of *Scirpus* makes it a surf-plant *par excellence*, and it is of cosmopolitan distribution in its favorite habitat. Yet at Lake of the Woods it is by no means so abundant as another plant of quite different appearance, by no means so perfectly adapted, yet occupying many exposed shores together with or to the exclusion of the bulrushes. This is the type of a second form of barrier in strong surf.

II. *Polygonum* barrier. The species thus established is *Polygonum emersum*, and especially off rocky points or islands it seems to flourish. Unlike *Scirpus* which appears to need

a bed of humus soil or at least highly nitrogenous sand for most favorable growth, *Polygonum* grows vigorously in crevices and may be described indeed as a crevice-plant, rooting under water. The stout stem, long pennant-like leaves, suggesting by their position in time of wind the well-known aspect of *Phragmites*, and strong attachment to the bottom make this plant an able cumaphyte although, it is true, it cannot structurally be regarded as the equal of *Scirpus lacustris.*

Barriers in light surf. Of these three types are represented at Lake of the Woods.

I. *Phragmites* barrier. This, with *Phragmites phragmites* as the dominant plant, which is of cosmopolitan distribution in regions of light surf, is well developed on the shoreward face of *Scirpus* barriers, and very often exists without the *Scirpus* fringe, in coves and protected bays. It cannot, however, exist off a shore where the surf is heavy unless protected by a *Scirpus* zone. The formation is well developed near the mouth of Rainy river and in the Northwest Angle bays.

II. *Spiraea* barrier. The plant is *Spiraea salicifolia*, a species as noted above, with wide range of habitat, and characteristic throughout the Lake of the Woods region as a crevice-plant on rocky shores. It commonly grows submerged a few inches and occupies a zone inside of the *Polygonum* zone, thus bearing often the same relation to *Polygonum* that *Phragmites* does to *Scirpus.* With its stiff stems, slender long leaves and firm roots, it withstands a considerable washing of the waves and seems to flourish well although submerged for a considerable portion of the summer. In autumn or in midsummer the water falls below its spring level and the foothold of the *Spiraea* becomes dry. The peculiarity of structure in the plant which enables it to grow partly submerged or in dry rock crevices fits it particularly for the extreme shores of rocky islands, and here, as for example on the southern points of Oak island it grows abundantly.

III. *Salix* barriers. Like the *Spiraea* barrier this is connected with fluctuations in the lake level. The components are members of the genus *Salix*, but one species in particular, *Salix fluviatilis* is most prevalent as a surf barrier. The habitat chosen is off drift-shores, the plant seeming to prefer a region of sand to one of rock-crevices or submerged humus. Consequently since rocky islands with drift dropped upon one shore and not upon the shore opposite are common in Lake of the Woods, it often happens that a zone of *Salix* will be established at the

water's edge in the former case and a zone of *Spiraea* in the latter, upon the same island. Thus a distribution today of plants upon the island shows the line of advance of the ancient glacier quite as clearly as striae would. Such a fact indicates well the long-standing nature of some of the causes regulating plant-populations.

In general the *Scirpus* barriers backed with *Phragmites* or either of the two developed separately, will indicate a rather flat nitrogenous type of bottom with the country rock well silted over. The *Polygonum* or *Spiraea* barriers indicate a bare irregular rock bottom with humus laden crevices. *Salix* barriers are indicative of drift collection. When one of these barriers is fully established the area often becomes tenanted by *Potamogetons*, upon which the force of the waves is modulated. But large leaved plants do not collect in the barrier zone unless it is broad enough completely to calm the "white caps" that come in from the open water. Nor do small floating plants like *Lemma* find it easy to remain in the interstices of the barrier, so the subsidery vegetation is sometimes reduced to the various algae, *Cladophoras*, *Gloeocapsas*, *Scytonemas*, etc., that cling to the stems of the dominant bulrushes or reed-grasses.

ROCK SHORES.

Shores of this type are almost invariably creviced, and when crevices are formed they interfere with the regular zonal distribution of the plant population to such an extent that almost all rocky shores will be better considered under the general head of azonal formations. This is particularly true of talus shores, for in the case of smooth rock in place there is usually a well marked zonal distribution with reference to the water line. Below high water mark on such shores the lichen flora differs from that established above high water mark if the shore be steep, rounded or shelving, but if it be flat and a trifle above the water line, as sometimes, there is not only zonal distribution of the ordinary type to be observed, but very often too that biological distribution from a common center that is perhaps best indicated in the "fairy-ring" mushrooms of meadows and fields. On such flat rocks circles are marked out by the growth of rock-lichens, and these overlap and interlock in an interesting fashion. A general view of lithophytic vegetation may be postponed until the azonal shores are considered and here only a few points regarding the ordinary zonal distribution need be remarked upon.

Flat shores of rock. If crevices are absent the population consists of lichens and mosses. The action of surf regulates somewhat the distribution, and upon such shores algal pools like those previously described for front strand are common. The wet area nearest the lake may be termed the *Endocarpon* zone, from the prevalence of lichens of this genus; the zone next inland as the *Biatora* zone, and the one farther yet toward the country-line as the *Cladonia* zone.

Rounded shores of rock. The same zones are established here except that they are not so broad. Generally a growth of *Endocarpon* just at the water's edge is succeeded within a few inches by the other two, so that *Cladonias*, which, with *Stereocaulon paschale*, grow in great profusion on all such shores, occur within a couple of feet of the high water mark. Yet the exposure of the shore, as regulating possible surf-activity, has much to do with the breadth of the zones and the interesting observation may be made that on sheltered islands with smooth rock shores the *Cladonias* grow much nearer the water's edge than on exposed shores. Where the rock is particularly smooth there is greater difficulty in the establishment of the *Cladonia* zone, and its place is in many cases occupied by a zone of *Umbilicarias* Such an *Umbilicaria* formation is beautifully developed on the western end of the Isle de Massacre. In addition to the lichen flora some small lithophytic mosses are established upon smooth rock surfaces, but since the mosses are almost always crevice plants they may be better considered later. In the background of *Plate LXXVIII* a rather precipitous rocky shore is shown with few crevices near the lake, and here the zonal distribution of the lichens was apparent.

In general, since the lower plants are not particularly a matter of study in this paper, it may be said that flat or rounded smooth rocks offer so little foothold to plants that, although the conditions are favorable to zonal distribution, yet only lowly plants partake of it and the account need not be prolonged. It is sufficiently apparent that differences of exposure, of contour, of color, degree of hardness, chemical composition, illumination and irrigation must produce differences in the lichen population, but that a fundamental tendency to appear in zones is nevertheless discernible underneath the variety induced by the differences mentioned.

SOIL SHORES.

Of zonal shores of this character, not already discussed, really the only examples are the mud flats and mud banks, which are so rarely developed on Lake of the Woods. All other soil shores are largely azonal. For a soil shore can hardly be maintained, except as morass which has been considered by itself, or as humus or drift, quite outside the sphere of wave-influence.

Mud flats. Upon these shores the algal pools are prominent, and in them commonly *Lemna* is developed in small quantities, so they may properly be denominated *Lemna* pools. If the mud flat be not inundated too frequently, as is almost uniformly the case, a few *Carices* may be established, but in Lake of the Woods, with its considerable variations of water stage, such areas are commonly barren, if they appear at all. Barren mud-flats differ from morasses principally because they are thus barren. Yet on such shores an outward zone of *Lemna* pools is often backed by an area of *Carices*, and the whole constitutes a temporary formation easily destroyed whenever the mud is rearranged by the action of the waves. Upon such shores, if they be in proximity to a bed of *Nymphaea* the pond lilies often creep, and during the summer the edge of the flat may be tenanted by these almost amphibious plants.

Mud banks. These are always small in extent, and often appear as the most temporary of formations. Sometimes deltas of mud and silt are deposited upon strand or upon flat rock shores by small temporary streams, and thus a peculiar group of nitrophytic plants will be established upon the strand. In other cases the mud bank is developed from a mud flat, when the ridge is tenanted by *Carices*, small *Ranunculi*, *Veronica*, sometimes *Scutellaria*, and in brief is like the zones established around pools in the back strand, as previously described. Although nitrogenous, these mud shores are so impermanent that no opportunity for plants of high rank to develop is offered.

Coming to a consideration of azonal shores, and the methods of distribution upon them, it is worth noting that very often little complexity of distribution, at first sight, characterizes these areas. The solid *Populus* or *Betula* formation extending to the water's edge seems homogeneous, and unless it is studied in detail might be mistaken for a true zone. Yet, often such shore floras are quite azonal, and should be regarded rather as

very complex than as very simple formations. Thus it happens that in the case of shore formations one is not always able to speak with exactness unless an examination of the formation, and of its development as well, is made in great detail.

Azonal distribution has been described as characteristic of topographic features devoid of radial symmetry. Hence talus heaps, boulder ledges and irregular rock masses are favorable regions for the development of an azonal formation. Often, too, the azonal formation appears as a preliminary stage in zonal distribution. This is particularly well exhibited on burnt shores. When the vegetation has been removed by fire, the new vegetation springs up quite in the azonal manner. So that a burnt shore which might have had well marked zonal population will perhaps be covered with a solid formation of light seeded plants such as *Populus* and *Epilobium*, these having easily reached the shore by the agency of the wind. And if the soil itself was destroyed by the fire, then an azonal formation of lichens and mosses will gradually establish itself and only after the lapse of years will the delicate influences that regulate the zonal grouping of plants make themselves felt over this area. In addition to the more permanent azonal formations, there should, then, be noted these temporary azonal groups on burnt areas. In such cases the azonal distribution may be established and may maintain itself for some time upon tracts which are not devoid of radial symmetry. But this need not be confusing, for commonly such a new formation can easily be distinguished. For example, a uniform *Populus* growth along some shore with all the trees of an age may be classified as azonal, perhaps, while another growth with a regular increase in age of the trees from one side of the strip toward the other, may be classified as zonal.

The various areas of azonal distribution may receive brief consideration in their order.

TALUS.

Naturally the character of the talus depends upon the ledge from which it fell. The chemical composition of the rock, its cleavage, bedding and tilt, its mass, slope and height, the slant of the lake bottom and numerous other considerations regulate the coarseness, the extent, the inclination and the habitability of the talus. In most cases, however, talus composed of large blocks with slight admixture of humus may be re-

garded as relatively new, while that in which the blocks are smaller and the humus content greater, may be considered as of greater age. This is not always the case. It happens sometimes that talus falling from granite or other ledges of resistant rock, lies along the shore in such a position that the water laps among the fragments, carrying away much of the organic material which might temporarily accumulate, and thus for a very long time the blocks remain with the look of new talus except for the development of lichens in luxuriance on the fragmented faces of the rock. The different types of talus that have been observed may be noted in their order.

Coarse talus. This is of two classes, new talus, and old talus. The coarse new talus is known by the scanty development of lichens on the rock surfaces of fragmentation, the coarse old talus by the disappearance of distinction between block-surfaces originally exposed and surfaces exposed by the fracture. A number of types of plant societies may be observed upon such areas. If the blocks are very large and creviced the distribution is the same as that yet to be described under the head of rock shores. Disregarding such a condition one may indicate the following special formations.

I. Thallophytic talus formations. The blocks are not strongly creviced and the only plants able to gain a foothold are the lichens and algae. Such formations are the first to appear on new talus blocks, unless conditions of drainage and silt-deposition complicate the matter. They may also characterize old talus-block surfaces when the shape of the fragment is unfavorable for soil accumulation. The character of the plants and their relative abundance vary with the exposure of the surface, one being lighter, warmer, more sheltered from the wind than another.

II. Archegoniate talus formations. The characteristic plants are mosses and ferns. The blocks that show this type of plant population are generally along quieter shores where high winds and surf are not troublesome. If the block be not too large it may become covered down to high water mark with luxuriant growths of *Hypnaceae* and *Polypodium*, to the almost complete exclusion of other plants. If, however, the block be of sufficient size and proper inclination and surface contour to permit the accumulation of a soil, it may harbor many small lithophytic flowering plants, and as the block grows older perhaps even shrubby or arboreal vegetation may be established upon its slowly gathered superficial coating of soil.

III. Herbaceous talus formations. The characteristic plants are various grasses, *Campanula*, *Heuchera* and *Houstonia*. Such grouping arises even on small talus blocks of relatively new formation if the surface condition is such as to retain the soil that is formed, or to hold soil or silt of drainage.

IV. Shrubby talus formations. These may be coniferous, with the Junipers as the dominant plants, or metaspermic, with such plants as *Populus*. Much depends upon the vegetation of the back country in the establishment of shrubby talus groups, yet light seeded plants like *Populus* have an evident advantage. On large talus blocks it is not uncommon to see small shrubs of *Populus tremuloides* rooting themselves, together with diminutive plants of *Pinus divaricata* or the Junipers.

V. Arboreal talus formations. On talus blocks it is not common to find large trees established, unless the block itself is so large that it might well be considered under the general class of rock-shore. Yet sometimes a talus block with a pocket-like depression may collect soil in this depression and give foothold for a tree. The tree in such a case is almost always coniferous, the hardwoods preferring crevices.

All of these types are pure talus types and no consideration to the intermixture of sand or soil that begins as soon as a talus slope is established, has been given. In each of the five groups a trace of zonal distribution is to be discovered, occasioned by the difference in exposure of the perpendicular surfaces, those toward the lake being differently affected from the ones facing in other directions. Yet, since the blocks may be close together, they shade each other to such an extent that the whole slope can hardly be regarded as a symmetrical area of plant establishment, and the distribution is characteristically azonal.

Of the pure talus-block type of distribution there are a great many varieties owing to differences in exposure, slope, temperature, illumination, moisture and biological conditions. On the whole, such formations are less abundant than the mixed talus. Coarse talus may be filled in either by sand from the lake or by soil derived from one of three sources—from the off-shore vegetation, from the talus-block vegetation or from inland areas whence it drains down upon the talus slope. However, it may happen, very commonly the spaces between talus-blocks come to be filled with soil or with sand. In the first instance there develops in a coarse talus-bed about the same conditions that

characterize creviced rock and a distribution of plants like that of creviced rock comes to exist where originally there was a pure talus type of distribution.

VI. Talus and soil formations. Upon the humus masses of the interstices a group of plants become established such as habitually occupy rock crevices. The characteristic species are *Spiraea salicifolia, Houstonia purpurea, Heuchera americana, Campanula rotundifolia* and *Ambrosia artemisiaefolia.* But if the accumulation of soil has progressed to such an extent that larger plants can gain a foothold, one finds upon the talus slope abundant forests of pine and hardwood timber. One of the favorite habitats of *Pinus divaricata* throughout the Lake of the Woods region seems to be the talus slopes with soil admixture, and they grow almost as vigorously when established as crevice plants on the rock shore, where *Pinus strobus* is also abundant.

VII. Talus and sand formations. Where they occur these are most clearly a mixed type of distribution. I have seen on Shoal lake masses of talus-blocks, three or four feet cube covered with *Hypnum* and *Polypodium*, lying imbedded, as it were, in a sandy beach tract bearing *Elymus* and *Prunus pumila.* No doubt the only proper explanation of such a remarkable juxtaposition of plants is the assumption that the low talus slope was first established and that afterwards the sand was washed in by the waves. Thus a composite formation was developed. Extremely old talus with small, weathered blocks and sand infiltration can not ecologically be distinguished from boulder drift shore.

A view of talus with formation of *Populus tremuloides*, coming under *Group V* of the classification is shown in *Plate LXXVIII*, to the right in the background. This is a characteristic azonal talus population on an area with considerable soil substances infiltrated by drainage from the higher back country.

A variety of mixed talus types with coarse talus as the foundation might be discussed with profit—for example, the buried talus-blocks of some of the northern islands, where a general coating of soil covers the talus masses but lies deeper over the interstices than over the rock fragments, or the talus-blocks imbedded in morassic shores and the influence of their presence upon the formation of *Scirpus* or *Salix* belts—but the problems are of such endless complexity that they can hardly be entered upon in this preliminary sketch.

Fine talus. This name is applied to those talus slopes upon which the process of weathering has progressed to such an extent that the talus blocks are all broken up into small fragments. Together with this process there is always a deposition of soil in the interstices, part of this soil being derived from original talus vegetation, and part of it from drainage of silt upon the slope. Such slopes do not become established rapidly in the Lake of the Woods region and a slope covered with fine talus and soil is evidence of a long history and many rearrangements among the plants which tenant it. A number of formations might be described upon such slopes, but it should first be noted that as the slope becomes more even and regular, owing to the weathering and infiltrating processes, a tendency towards zonal distributions arises and many fine–talus slopes have well marked zones of plants established upon them. One or two formations on fine-talus are, however, of special interest. The following have been observed at Lake of the Woods:

I. Fine-talus lichen formation. The species are mostly *Cladonias* and *Stereocaulons*. The soil-dwelling *Cladonias* e. g. *Cladonia pyxidata* are abundant, mixed with crevice-dwelling and lithophytic forms, such as *Cladonia rangiferina* and *Stereocaulon paschale*. Upon such a talus slope there are abundant mosses, *Barbulas*, *Bryums* and *Polytrichums*, and an admixture of small grasses and herbs. The lichens, however, give the character to the formation.

II. Fine-talus fern formation. Upon slopes of fine talus it is not uncommon to find a formation consisting almost exclusively of *Dryopteris* and *Polypodium*. Such slopes are generally inclined at an angle of about 45° to the plane of the lake level. They seem to develop well in rather open, unsheltered places. Such a slope is well developed on Trim-tree island in the Little Traverse.

III. Gramineous talus turf. Here the dominant plants are members of the genus *Agrostis*, and over the slope a pretty even turf of *Agrostis hiemalis* is often formed. The loosening of the soil by the small stones imbedded in it seems to favor the growth of this grass, and such slopes have been observed at several different points on the islands of the lake.

IV. *Sambucus* talus slopes. The characteristic plant is *Sambucus pubens*, the elder-bush. This, with bushes of the red raspberry (*Rubus*) forms a rather characteristic shrub on certain talus slopes, especially toward the periphery of small islands, not too elevated nor with strongly precipitous shores.

It is also found at Lake of the Woods as the typical "inner shrub" on dome-shaped islands, as described by me elsewhere,[9] and can not be regarded as a pure talus-type of plant formation.

V. *Betula* talus-slopes. Growths of *Betula papyrifera* sometimes occur on fine-talus, although usually the soil-content is so considerable that the shores are better described as humus shores. Yet *Betula* woods upon some of the islands mark the fine-talus as sharply as *Populus* or *Pinus divaricata* woods mark the coarse talus.

VI. *Pinus resinosa* talus slopes. This species of Pine, the "Norway pine" of Minnesota loggers, does not commonly grow upon shores at Lake of the Woods, but is rather a back country plant. Isolated individuals occur in various localities, in crevices, on the strand, on dunes and on coarse talus. Special colonies have been noted in three instances on fine talus slopes, The exposure was slight, the slope gentle and the admixture of soil considerable.

Without extending the examination of coarse and fine talus farther it may be observed that while coarse talus gives slight opportunity for zonal distribution, fine talus, after the sufficient lapse of time offers an area suitable for zonal distribution. This is especially the case if the slant of the bed is gradual and the admixture of soil such as to bury the talus-fragments in a homogeneous mass of humus. A large number of transition types, mixed types, compound and irregular groupings, may develop upon talus areas. The age, coarseness, slope, extent, exposure, drainage, off-shore conditions of the bottom, chemical composition of the talus blocks, juxtaposition of the blocks, percentage of interstitial deposits and their character, and back country biological conditions all influence and determine the nature of the talus population.

BOULDER SHORES.

Ecologically coarse boulder shores do not differ strongly in themselves from coarse talus, nor fine boulder shores from fine talus. But the conditions of their development are sufficiently different to expose them, when formed, to a different set of influences. While talus shores may occur in quiet secluded regions of the lake, the boulder drift is found principally on very open shores where there is strong wind and surf activity.

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(9) **MacMillan.** Distrib. of Plants, etc. Bot. Gaz. **22**: 218. 1896.

Thus the boulder shore is developed excellently on the side of Big island facing Garden island, quite open to the winds and waves of the Grand Traverse. This difference in exposure gives to a boulder shore more the character of strand, but, because of the irregular surface, strand zonal distribution does not readily arise. although there is commonly formed a group of plants back on the shore somewhat analogous to back-strand. According to contour two types of boulder shore may be distinguished, the flat or *boulder strand*, and the rounded or *boulder slope*. If the boulders are large the conditions are not the same as if they were small.

Coarse boulder shores. Such a name may be applied to those shores where boulders a foot or more in diameter are bedded in sand or soil. That they should be bedded in soil is possible only in sheltered coves or behind surf barriers. Ordinarily they are bedded in sand.

I. Boulder strand. This name may be applied to low-lying beaches which are covered with half-buried boulders of large size. The boulders themselves support a lichen population with occasional growths of moss or even of ferns, but the latter condition is rare. The intermixed sand bears ordinary psammophytic plants and the combination presents much the aspect of talus and sand as described above. A difference, however, lies in the greater exposure of such a shore, so that the lichens are scanty, dwarfed and not of the *Cladonia* types, but rather *Endocarpons*. Amid these lichen-groups an algal flora may flourish in boulder-strand-pools, the boulders themselves, by their interference with the regular wash of surf, favoring the development of strand pools. And neighboring closely upon the pool-flora and the lichens will be the *Ambrosia*, *Epilobium*, *Onagra* and *Elymus* vegetation of typical beach. The boulders offer shade and shelter, to some extent, so the strand herbs become distributed with reference to them rather than to the general shore line, as in ordinary strand. Coarse boulder strand is, then, to be regarded as an azonal modification of ordinary strand.

II. Boulder slopes. Like talus slopes, these may have a greater or a less percentage of enclosed humus and the character of the vegetation varies with the percentage. Usually, however, unless recent denudation has been in progress, the shores are strongly nitrogenous and separate into two areas, upon analysis. The region nearer the water's edge differs from that farther back and maintains a plant population of a

distinct type. Thus, to this extent, there is zonal distribution but the irregularity of surface is so considerable that the preponderance of characters are azonal. Where the water in its fluctuations of level exerts an influence it is commonly to wash out the organic debris from among the boulders and thus to decrease the nitrogenous per cent. This is not entirely a one-sided interchange, for where aquatic algae, as for example, *Aphanizomenon* are developed in enormous quantities they are often delivered by the waves among such boulder-shore interstices to an extent that can only be appreciated when one has seen the great drifts of decaying algae that sometimes occur in mid-summer, upon such banks as are able to retain them through irregularity of surface. The region next the water's edge does not usually maintain large trees, although occasionally willows or poplars may stand on the extreme outer border of the shore, while behind are shrubs and herbs. More ordinarily the edge of such boulder slopes is occupied by plants of *Spiraea*, *Amelanchier*, *Salix*, *Campanula*, *Alnus*, *Heuchera* and a general mixture of psammophytes, lithophytes, nitrophytes and hydrophytes that indicate by their irregular juxtaposition the complexity of the substratum as an ecologic area. Farther back forest growths of *Populus*, *Betula*, *Pinus*, *Quercus*, *Fraxinus* or *Acer* may be met with and the general slope maintains a greater variety of plants than is often found on areas of similar size, in the region of description. In *Plate LXXVII*, a typical boulder-slope is shown with a front-slope group of azonally distributed shrubs and herbs, and a back-slope formation of mingled *Betula* and *Populus*. This view is taken in MacPherson's bay and shows also an Indian village with the birch-bark canoes of the aborigines drawn up upon the shore.

Boulder slopes having been established in the Glacial period are not at all comparable to new talus, but only to the oldest. Upon the boulders themselves, lithophytic lichens and mosses are commonly abundant and shores consisting of boulders buried in humus or the sand have their distinctive characters of plant population as was described for the shores of buried talus.

Fine boulder shores. As in the case of talus shores a distinction arises when the rock fragments are small. In such instances they are easily buried by humus or by sand and the characteristic lithophytic vegetation does not appear. This type of shore occurs either as strand or as slope. The fine

boulder strand may be termed gravel-beach for this is the form it usually takes.

I. Gravel-beach. Upon beaches that are composed altogether of a coarse gravel the pebbles are so readily moved about by the surf that vegetation finds great difficulty in establishing itself. Consequently the area of a gravelly beach nearest the water's edge is commonly quite sterile. Not even do pools of algae find it easy to become established. Farther back, however, scattered herbs and shrubs can gain a foothold. The segregation of pebbles that goes on under the lapping of the waves, or under surf impact, is such that the smaller are often thrown well inland while the larger are left upon the extreme front of the shore. Consequently a strip of small grasses and herbs usually occupies the shoreward portion of the strand, and these plants, that are thus established, are strongly lithophytic in character. Hence upon such gravelly beaches one finds *Campanula* and *Heuchera* in great profusion, together with *Agrostis*, *Ambrosia* and *Onagra*, a very different population in its appearance from that of sandy beach. Still farther back a group of psammophytes often comes in so that there is strong semblance of zonal distribution. Indeed so far as the plant distribution is affected by the action of the waves in segregating the pebbles, it is truly zonal. It is classed under the general azonal type because of its habitat and strongly azonal method of development. Upon a new gravelly shore the distribution is quite azonal. The gravel beach may properly be regarded as an intermediate type of formation.

II. Gravel slopes. Such rounded slopes, covered with *Epilobium*, *Onagra* and *Rhus*, are seen on Garden Island. The subsoil seems to be of sand and clay, and the humus sheet is thin. Yet a group of shrubs, developed in quite irregular and azonal fashion, are able to establish themselves and persist. Much of the organic matter is drained out of the soil through the subsoil, and the slopes are, as a whole, where studied, not highly nitrogenous. The number of plant species is therefore limited and consists chiefly of low shrubs. I have seen no lichen or moss-covered gravel slopes, such as are developed from talus. Probably the rounded shape of the pebbles favors more ready drainage-off of organic substances than the irregular, angular shape of the talus fragments. If this be true it is an interesting fact to notice. Evidently the paucity of species, determined by rapid drainage and consequent low nitrogen-

content of the soil, must be referred eventually, as one studies the phenomenon, to the rounding, polishing action of ice in the Glacial period. Perhaps no better illustration than the difference in plant population between fine talus slopes and gravel-slopes could be given to illustrate the antiquity and multiplicity of causes that determine the plant-physiognomy of any given region.

ROCK SHORES.

While many rocky shores show true zonal distribution of their plant population, this is not usually the case. When the surface of the rock is irregular, the whole split by a network of crevices, and covered here and there with little pieces of talus, a lack of symmetry arises which finds response in azonal distribution of the plants which tenant the area.

Irregular surfaced rock shore. Very often the irregularity of the surface arises from wave action, very often from weathering, recent or preglacial, and in some cases it is the direct result of glacial abrasion, as may be seen at the Northwest Angle. However developed, the result is much the same so far as concerns the distribution of plants. In the hollows and crannies soil will collect, either by drainage-in or by adjacent formation through the activity of lichens, mosses and ferns, and these soil pockets, irregularly distributed, of varying depth and extent, give rise to a considerable variety of plants. A list of rock plants on the extreme northwestern point of Big Island is given here to indicate what are the dominant species.

Rock group on Big Island point.

Dryopteris thelypteris.
Polypodium vulgare.
Juniperus sabina.
—— communis.
Taxus minor.
Agropyron tenerum.
Agrostis alba.
—— hiemalis.
Elymus canadensis.
Muhlenbergia mexicana.
Panicum dichotomum.
Carex canescens.
Cyperus strigosus.
Juncus tenuis.
Unifolium canadense.
Quercus macrocarpa.
Actaea alba.
Anemone canadensis.
Ranunculus macounii.
Capnoides micranthum.
Arabis hirsuta.
Heuchera americana.
Cerasus virginiana.
Potentilla arguta.
Rosa blanda.
Spiraea salicifolia.
Oxalis stricta.
Hypericum ellipticum.
Chamaenirion augustifolium.
Onagra biennis.
Aralia racemosa.
Verbena hastata.
Mentha sativa.
Stachys aspera.
Vleckia anethiodora.
Plantago major.
Galium boreale.
Lonicera dioica.
Campanula rotundifolia.
Ambrosia artemisiaefolia.
—— psilostachya.
Eupatorium perfoliatum.
Euthramia graminifolia.
Hieracium canadense.
Lactuca canadensis.

Apparently the character of plants established upon an irregular rock surface is conditioned upon a great variety of causes. The size of the soil pockets, their depth, their opportunity of accumulating moisture, their temperature and illumination, their proximity to or remoteness from the waves, their exposure to winds, and, in short, all the ecologic factors enter into the problem and the prediction of definite species in soil pockets of known size and depth would be impossible, so much influence would the surrounding and secondary causes exert. Yet one could name a number of plants not to be found in such pockets and could limit the prediction within bounds. Even this would sometimes expose a novice to difficulties for very unexpected plants occupy these little pockets on an irregular rock shore. For example on Windigo island, near Flag island, the pockets, two or three square feet in extent and two and a half inches in depth, in granitic rock were occupied over a considerable area almost exclusively by *Sphagnun cymbifolium*, a most unexpected locality. The plants apparently drew upon adjacent trees of *Pinus divaricata* established in crevices, for shade and for sluicing the rain water into their little hollows. These miniature peat bogs upon high, wind swept rocks, I have not happened to encounter elsewhere. In one of them several individuals of *Moneses* and in another a plant of *Kalmia* had become established.

Whether the pocket vegetation shall be lichens, mosses, herbs, shrubs or trees, depends much upon the depth of the pocket, its drainage supply and the environmental factors. In these soil pockets the incalculable factors of distribution, such as the dropping of seeds by birds, or by the wind or by roaming animals, are so important that the vegetation aspect of the region is quite unpredictable in its details. In the foreground of *Plate LXXX*, the Sacred Rock of the Lake of the Woods Indians is shown. One observes the irregular surface. The depressions are very shallow; thus small amounts of soil develop and only small plants—grasses, mosses and lichens—are shown. In the background a coarse talus slope, with *Populus* vegetation, appears. In *Plate LXXIX*, on the other hand, deep pockets have been formed over the rock surface and on them a forest of *Pinus strobus* is established. Mingled with this species are crevice trees of *Pinus divaricata*. The two plates give a good idea of the influence of surface contour of the rock substratum upon the plant physiognomy of the region. The difference between the two shores is essentially one of surface contour. Other factors are slight as compared with it.

Creviced rocks. Crevice-formation is indeed only a variety of irregular surface contour, but from the cleavage of the rock in straight lines intersecting each other, vegetation rows are often established. The crevices, if of long standing, have commonly been filled with soil and are occupied by their characteristic plants. A large list of crevice dwelling plants might be prepared from the general catalogue of Lake of the Woods vegetation, Scarcely a plant of the region, except the true aquatics, like *Utricularia* or *Potamogeton* is altogether unable to maintain itself in a crevice. Yet, notwithstanding this fact, there is a limited group of omnipresent crevice plants which appears on almost every shore. These may be divided as follows:

I. Crevice thallophytes. Here are included a number of lichens, especially *Cladonias*, with which the region abounds, mosses and ferns. *Polypodium* and *Dryopteris* are the most abundant crevice-fern genera. Often a creviced shore is marked off with intersecting lines of green and white, the green being crevices filled with *Polypodium*, the white, crevices tenanted by *Cladonia*.

II. Crevice herbs. The dominant crevice-herbs are doubtless *Campanula rotundifolia*, *Houstonia purpurea*, *Heuchera americana*, *Agrostis hiemalis*, *Arenaria stricta*, *Achillea millefolium*, *Ambrosia psilostachya*, *Apocynum androsaemifolium* and *Vleckia anethiodora*. As has been indicated above, many others may be encountered, but these are universal.

III. Crevice-shrubs. The dominant crevice-shrubs are *Juniperus sabina*, *Juniperus communis*, *Spiraea salicifolia*, *Rosa woodsii*, *Symphoricarpos*, *Rhus*, *Corylus*, *Diervilla* and *Cornus*. Crevice shrubs need no wider crevices than do the herbs, but what is lost in width must be made up in length or depth.

IV. Crevice trees. An interesting feature of the plant population is the ready adaptability of certain trees to live in narrow crevices. The forms most commonly found in such restricted quarters are *Pinus strobus*, *Pinus divaricata*, *Quercus macrocarpa*, *Fraxinus americana* and *Populus tremuloides*. It is remarkable to observe the ease with which pine trees six or eight inches in diameter maintain themselves in a crevice less than a foot wide, where the entire root system must dispose itself in the cramped space afforded it, and yet the pines especially thrive wonderfully under such conditions. Some islands, creviced sparingly, maintain what at a distance seems to be a fairly solid and homogenous forest of pine, yet upon close examination this forest will be discovered to consist entirely of

crevice plants, while between the crevices the rock is bare or maintains at best a few lichens and mosses. Upon high wind-swept rock shores at Lake of the Woods an occasional odd ecologic adaptation of the white pine is to be observed. Instead of growing in the ordinary way the plants lie flat like a Juniper and cover sometimes circles thirty yards in circumference with a dense low network of prostrate branches. One would scarcely recognize the plant as being *Pinus strobus* at all, except upon close investigation.

The crevice-tree formations are shown prettily in *Plate LXXVIII* in the background, on the left, where a steep smooth rock shore bears a vigorous crevice flora of *Pinus strobus* of the ordinary form and *Pinus divaricata.* Among the innumerable islands of the lower lake this type of shore is exceedingly common. It is well developed also in Shoal lake and in White-fish bay. Of the shores of the upper lake fewer are of this type, but some of the Northwest Angle inlet and Moose bay shores are perfect examples.

When a crevice-tree formation arises in a crevice running parallel with the shore-line the drainage often brings about the building of a concentric soil ridge, the trees serving as barriers to the general downward drainage from the back country, and thus a considerable zonal distribution may come into existence. When, however, the crevices run perpendicular to the shore-line such a condition does not arise. This origin of forest zones by drainage on dome-shaped islands, I have considered fully elsewhere[10].

Perpendicular rock shores. The distribution of plants upon precipitous cliffs such as those of Crow Rock island is not necessarily azonal. It has already been shown how an *Endocarpon* lichen zone may originate within the space of wave activity while above, other lichens, *Biatoras* and *Cladonias,* may become established. Yet upon the bold smooth face of a cliff for the greater portion of its surface only azonal or *biologically* zonal distribution of lichens, mosses, ferns and small crevice plants is ordinarily to be observed. In some cases large crevice-trees may establish themselves upon these precipitous faces. The most abundant plants, however, upon the precipitous cliffs, in all this region, are lichens of the genus *Theloschistes.* One may with propriety consider this as a typical formation.

10 **MacMillan:** Distribution of plants, etc. *l. c.*

I. *Theloschistes* formation. Enormous patches of these bright orange or red lichens may be seen upon the cliffs of the Lake of the Woods district. They are best developed on Shoal lake, on Crow Rock island, in Whitefish bay and upon the high rocks of Yellow-girl bay. Such cliffs acquire a highly colored appearance and seem to offer conditions more favorable for the development of *Theloschistes lychneus* and the others than do rocks lying at a smaller angle with the horizon.

II. *Umbilicaria* formation. Upon some precipitous cliffs vast numbers of *Umbilicaria* lichen-thalli are prominent. Such seem more copiously developed upon the irruptive rocks than upon the quartzytes and gneisses of the region.

III. *Polypodium* formation. Precipitous cliffs green with *Polypodium* are not uncommon. In this case there are small crevices, or at least an irregular surface to the rock.

IV. *Campanula* formation. When the surface of the cliff is seamed with small crevices *Campanula* gains a foot-hold, and often develops almost to the exclusion of other plants.

V. *Juniperus* formation. Upon some vertical cliffs with numerous larger crevices an almost solid formation of *Juniperus communis* has been observed.

In general it is apparently a characteristic of the precipitous cliff that its plant population is homogeneous. Where upon a flat rock surface of the same area a dozen or more species would be established, upon the precipitous cliff only half as many may be found. This fact illustrates the influence of rapid drainage, constant unilateral illumination, or general shade, and reflection or radiation of heat upon the plant inhabitants. A smaller number are able to endure the conditions of the perpendicular rock than can flourish upon the flat rock.

HUMUS SHORES.

Certain types of humus shores have already been considered. Morasses are regarded as a special type of such shores upon which a distinct zonal distribution is readily established. Mud flats may also be regarded as humus. Both of these, however, have been redistributed, to some extent, by the action of the water. It remains to note the occurrence of ordinary humus in place, along some sheltered shores. Conditions favorable for its development are as follows: the bank must be gently sloping, secluded from the wind, heavily wooded and thus shaded from the direct rays of the sun, undisturbed by running water, and of such general even contour that the soil-water

collects in no special sink-holes. Under such topographic conditions and adjustments of the environment, humus-banks, in some cases, develop almost down to the water's edge. Any violent wave action would destroy them, but they may bear a gradual rise and fall of level in the lake without becoming disintegrated. Upon such areas the true humus plants develop abundantly. Certain special formations have been observed.

I. *Onoclea* formation. Upon low humus banks the ostrich fern is sometimes established as the dominant plant. This happens on the shore of some small irregular islands in Moose bay. As a back country formation, *Onoclea* beds are conspicuous on Garden island and elsewhere. The *Onoclea* beds on humus shores have been observed covering areas of about 1500 square meters to the exclusion of other species.

II. *Pyrola formation.* The little pipsewissa plants are the dominant species but with them occur commonly *Unifolium*, *Gaultheria*, *Corallorhiza*, *Moneses*, *Goodyera*, *Gyrostachys* and many other small nitrophytes.

III. *Alnus* formation. The alder sometimes occurs as a dominant plant upon such humus banks. When thus established its root-tubercles are very copiously developed.

IV. *Taxus* formation. Upon humus shores of Garden island, this conifer is a dominant plant upon certain stretches. It occurs when the general back-country formation is coniferous.

V. *Abies* formation. The balsam marks a low humus shore and by its prevalence indicates rather the drier typical humus than the redistributed morassic humus such as *Picea* and *Larix* seems to favor as a habitat.

VI. *Betula* formation. Birch woods develop upon humus stretches and in such cases maintain a vigorous growth with an under-vegetation quite different from that formed when the *Betula* establishes itself upon talus. In the latter case *Epilobium*, *Apocynums*, *Asters* and other herbs not strongly nitrophytic are the subsidiary plants. In the humus formation *Lycopodium*, *Botrychium*, *Monotropa*, *Pyrola*, *Circaea* and nitrophytic lichens, fungi, and grasses of the genus *Poa* or *Homalocenchrus* are abundant.

Other formations no doubt arise in the Lake of the Woods district, characterized by the dominance of other plants, but those that have been defined will serve as indices of the ecologic conditions of humus shores. Such shores are quite azonal in their distribution of plants, but the question of illumination

becomes important as the lake is approached. A grouping of the humus plants into those which can endure the strong illumination near the edge of the *Betula* wood, for example, and those which must have the deeper shade is effected, giving rise to a rudimentary zonal arrangement even here. *Moneses* is so essentially a shade-loving plant (*ombrophile*) that it does not approach the edge of the wood, but remains in the deep shadows. *Corallorhiza*, on the other hand, prefers a station nearer the edge. Comparative tests of the different humus plants with reference to their degree of ombrophilic instinct would be useful, and could be made in such a region.

CONCLUSION.

The principal formations as studied at Lake of the Woods, have now been passed in review and their characters noted and commented upon. No extended summing up is necessary for it must be apparent that the purpose of the paper has been but a single one—to point out the dependence over such an area as the shores of the lake, of plant formations upon topographic and environmental conditions. It has been shown how each formation may be explained briefly as connected with a certain *melange* of outward conditions, and an effort has been made to analyze these conditions both by themselves and as connected with the growth of vegetation. Such an account, the first of its kind published in America, may be of service in stimulating ecologic study of plants, and if it be so fortunate its author will be well satisfied and repaid for some months of arduous work in the field. There is no question that the study of plant distribution over limited areas must be pursued more laboriously than ever, if the large problems of distribution are to receive accurate and authentic solution. Ecological distribution as a field of botanical research needs many students.

DESCRIPTION OF PLATES.

PLATE LXX.

Strand vegetation on Garden island. *Salix* front strand formation, with *Salix* mid-strand in background.

PLATE LXXI.

Strand vegetation on Oak point. *Prunus* and *Elymus* mid-strand in foreground. *Prunus* and *Rosa* back strand to the left.

PLATE LXXII.

Strand vegetation on Isle aux Sables. *Cornus* and *Salix* mid-strand in background. *Populus* and *Quercus* back strand in foreground.

PLATE LXXIII.

Dune vegetation on Isle aux Sables. *Populus*, *Prunus*, *Juniperus* and *Elymus.*

PLATE LXXIV.

Dune vegetation, Isle aux Sables. *Populus*, *Artemisia* and *Elymus* in foreground. *Cerasus* and *Celtis* in background.

PLATE LXXV.

Dune pool, Isle aux Sables. *Eleocharis* formation surrounded by *Prunus pumila*, *Juniperus sabina* and *Houstonia.* *Cerasus* and *Celtis* formation in background.

PLATE LXXVI.

Morassic shore, Echo bay. Zones of *Scirpus*, *Salix*, *Cornus*, *Populus* and *Pinus.*

PLATE LXXVII.

Azonal boulder slope on MacPherson's bay. Showing *Betula* formation in background, with *Epilobium*, *Spiraea* and *Calamagrostis* formation at water's edge.

PLATE LXXVIII.

Creviced rock and talus formations, near Rat Portage. *Campanula*, *Heuchera* and *Juniperus* formation at water's edge. *Pinus* and *Populus* formations in background.

PLATE LXXIX.

Irregular surfaced rock formation, near Keewatin. Showing *Pinus* formation.

PLATE LXXX.

Rock and talus formations on Flag Island point. Showing *Populus* formation on drift and trees. *Aristida* and moss formations in crevices of rocks in the foreground.

PLATE LXXXI.

Map of Lake of the Woods. After the map of the *Canadian Geological Survey*, with some modifications, especially in American waters.

LI. THE ALKALOIDS OF VERATRUM. I.

GEORGE B. FRANKFORTER.

HISTORICAL.

The genus Veratrum is represented in Minnesota by *Veratrum viride* Ait., a plant reported from Stearns county by Garrison, and probably distributed over the northern portion of the state. While not apparently abundant, it could doubtless be made to grow under cultivation throughout Minnesota, for its general range in North America is a broad one. The popular name of the plant is *Hellebore.*

The substance commonly known in pharmacy as veratrine, varies widely in its composition, chemical, physical and physiological properties. Until recently it has been exceedingly difficult to obtain different samples with the same general properties. The introduction of the so-called "Merck veratrine" has changed matters somewhat, although samples of the Merck alkaloid have been found to vary considerably in their general properties.

One of the chief causes of this exceptional variation is the extreme difficulty with which the alkaloid crystallizes, thus almost excluding one of the most important means of purification. Another, and perhaps the most important reason for this wide variation, lies in the fact that almost every one of the early investigators of the "veratria" has given the name to a different alkaloid or to a mixture of alkaloids.

In 1819 Pelletier and Caventou[1] obtained from *Veratrum sabadilla* an amorphous base, which was afterwards shown to be a mixture of several alkaloids. For some time this was sold as a medicine under the name "veratria."

Later Couerbe[2] in an examination of the sabadilla, obtained three distinct alkaloidal substances. One of these, the most abundant, was amorphous but formed a crystallizable sulphate

(1) Annal. de Chim. et de Physique [II] **14**: 69.
(2) Annal. de Chim et de Physique [II] **52**:352.

and chloride. He called the substance veratrine. The method which he used for the extraction is briefly as follows: The triturated seed was treated with 90 per cent alcohol allowed to stand for some hours and filtered. The alcohol was evaporated off when a dark colored varnish-like substance remained. The brown substance was then purified by treating the aqueous solution with dilute nitric acid, and the alkaloids reprecipitated by potassium hydroxide. The precipitate formed was filtered off, washed with cold water and taken up in 95 per cent alcohol. On evaporating off the alcohol, a yellow waxy mass remained which contained, besides veratrine, all the alkaloids present in the plant. To separate the sabadilleïne, the second substance, from the veratrine, the whole mass was digested with hot water. Sabadilleïne and the waxy substance dissolved. The residue was then treated with ether and that which remained on evaporating the ether was veratrine. This white varnish-like substance was repurified and analyzed. Two analyses gave the following: (1) C = 70.78. H = 7.63; (2) C = 70.48. H = 7.67, which corresponds to the formula

$$C_{34}H_{43}N_2O_6 .$$

The aqueous solution upon examination was found to contain besides the crystallized sabadilleïne, an amorphous substance which was like sabadilleïne soluble in both water and alcohol. It contained similar properties to sabadilleïne wax called sabadilleïne hydrate.

Castner[3] in a repetition of Couerbe's work concluded that the crystals obtained by him were directly or indirectly due to the presence of calcium phosphate in small quantities.

Ed. Simon[4] in an examination of *Veratrum album*, isolated two new alkaloids. One he called barytine and the other he named veratrine. The former after carefully examining, he changed to jervine (from *jerva*, a Spanish name for the deadly poison of the Helleb. alb.). The latter he identified as the veratrine of Couerbe. He obtained the alkaloids by treating the material with dilute hydrochloric acid, precipitating with sodium carbonate, extracting with alcohol and evaporating off the alcohol. They were purified by redissolving in alcohol, treating with animal charcoal, filtering and evaporating off the alcohol. The separation was made by dissolving in alcohol and adding dilute sulphuric acid. The sulphate of jervine is insoluble and can readily be removed by filtration.

(3) Arch. 88.
(4) Pogg. Ann. 41:569.

Wiegand[5] used a similar method for the extraction of the different alkaloids, but used a different method of separating them. He treated the whole of the crystalline mass with very dilute acetic acid, purified by animal charcoal and separated by dilute sulphuric acid and ammonia.

Merck,[6] in an examination of the base, described and analyzed by Pelletier, Couerbe and Dumas, found that when the amorphous substance was dissolved in exceedingly dilute alcohol and allowed to evaporate spontaneously, a fine white efflorescent crystalline mass was obtained which was insoluble in water. Analyses gave numbers for the formula

$$C_{64}\ H_{52}\ N_2\ O_{16}.$$

The sulphate, the chloride and the gold double salt were prepared and analyzed, analyses corresponding well with the above formula.

Weigelin,[7] in an examination of *Veratrum album*, isolated three alkaloids, veratrine, sabadilleïne, to which he gave the formula

$$C_{41}\ H_{66}\ N_2\ O_{13},$$

and sabatrine of the formula

$$C_{57}\ H_{86}\ N_2\ O_{17}.$$

The method of extraction was similar to that employed by Couerbe. The pounded seed was boiled with very dilute sulphuric acid and the extract treated with 80 per cent alcohol to remove the resinous matter. The alcohol was removed by evaporation and the boiling solution treated with ammonia. A resinous precipitate was formed which contained the veratrine. The latter was purified by dissolving in ether, evaporating, redissolving in alcohol and precipitating with water. The ammoniacal filtrate was agitated with amyl alcohol and allowed to evaporate spontaneously. The residue was then redissolved in common alcohol purified by animal charcoal. Finally, the concentrated solution of the veratrine was precipitated by ammonia. This residue was then extracted with ether. That which remained, upon evaporating the ether extract, was a bright red substance which was called *sabatrine*. An analysis gave numbers for the formula

$$C_{57}\ H_{86}\ N_2\ O_{17}.$$

The sabadilleïne was insoluble in ether and was repurified by reprecipitating from hot water.

(5) Jahrs. f. prak. Pharm. **1841**: 330.
(6) Ann. d. Chem. and Pharm. **95**: 200.
(7) Chem. Centralbl. **1872**:229.

The veratrine itself was obtained in two isomeric forms, one soluble in water, and the other insoluble. Analysis gave numbers which correspond best for the formula

$$C_{52} H_{86} N_2 O_{15}.$$

Mitchell[8] in an analysis of both *Veratrum viride* and *Veratrum album* found that the amount of alkaloids and resin varied in different lots of the root, due probably to different time of gathering. His quantitative determination of the alkaloids is interesting as compared with similar determinations made by Bullock[9], Peugnet and Salzberger.

Veratrum viride grains per lb.	Mitchell.			Bullock.	Peugnet.
Samples	1.	II.	III.	I.	I.
Veratroidine,	18 3	24.5	28.6	46.0	43.0
Veridine,				14.3	
Jervine,	16.0	18.2	20.5		7.5
Resin,	115.0	110.0	192.0		
Oily matter,	10.0	25.0	50.0		

Veratroidine is described as a white powder, uncrystallizable, of a bitter taste, producing a tingling sensation, and occasioning a violent irritation of the mucous membrane. It melts at 265° C. and forms salts with acids which are uncrystallizable. Alkalies reprecipitate the free base as a semi-crystallizable substance. The remarkable similarity of this base to cevadine makes it appear necessary that the *viride* should be re-examined.

Of equal interest is the quantitative determination of the alkaloids by Mitchell[10] and Salzberger[11] in *Veratrum album.*

Veratrum album, grains per lb.	Mitchell.	Salzberger.
Jervine,	10.0	7.5
Alkaloids soluble in ether,	35.0	
Resin,	220.0	
Oily matter,	124.5	
Protoveritridine,		0.25
Protoveratrine,		0.3
Rubijervine,	Quantity undetermined.	
Pseudojervine,	"	"

Schmidt and Köppen[12] obtained from the crude substance by dissolving in alcohol and allowing to evaporate spontaneously, well crystallized veratrine which corresponds well with the

(8) Pharm. J. Trans. [III]. 5: 768, 785, 847, 886.
(9) Am. Jour Pharm. 47: 449.
(10) Pharm. J. Trans. [III]. 5: 768, 785.
(11) Inaug. Dis. Erlangen. 1890.
(12) Ann. 185: 224.

crystals obtained by Merck. Seven analyses of the pure crystals gave numbers for the formula

$$C_{32} H_{50} NO_9$$

Although this formula seems to differ widely from that given by Merck and also by Weigelin, nevertheless when analyses are compared the difference in carbon and hydrogen is only small.

	Merck[13].				Weigelin[14].		Schmidt and Köppen.			
Analyses	I.	II.	III.	IV.	I.	II.	I.	II.	III.	IV.
C.	64.73	64.51	64.99	65.00	64.42		64.85	64.39	64.27	64.59
H.	8.84	8.55	8.76	8.7	8.70		8.56	8.81	8.58	8.68
N.	5.5				2.92	2.95	2.82	2 61	1.56	

It seems evident from the nitrogen determinations that the substance which Merck had in hand was not identical with that of both Schmidt and Köppen and Weigelin. This is also verified by the salts formed, the salts obtained by Merck being the only ones which were obtained in crystalline form. Schmidt and Köppen stated that when their veratrine was dissolved in acetic acid and treated with ammonia a part was precipitated while a part remained in solution. From this, they concluded with Weigelin that the alkaloid was capable of existing in two isomeric forms. They showed that the soluble form was capable of being changed back to the insoluble form by treating again with acetic acid and carefully neutralizing with dilute ammonia. Finally the identity of the two forms was estabished by comparison and analysis of the chlorides and the platinum double salts. The amorphous form melts at 150° to 155° C., while the crystallized form melts at 205° C. Couerbe gave the melting point at 115° C., while Pelletier and Caventou found a melting point of 50° C.

Wright and Luff[15] in a series of brilliant experiments on the alkaloids of the *Veratra* have thrown much light on what was hitherto regarded as a mass of contradictions. A sharp distinction was made between the several different bases which were up to this time known as veratrine. They showed that the substance described by Merck as veratrine is not identical with the veratrine of Couerbe, and that with a single nitrogen determination the analyses correspond, as has already been shown, with the base which Schmidt and Köppen had in hand and to which they ascribed the formula

$$C_{32} H_{49} NO_9$$

(13) Ann. **95**: 200.
(14) Chem. Centralbl. **1872**: 229.
(15) Jour. Chem. Soc. London. **33**: 338.

Of the three bases which have already been referred to, each has been known as veratrine. That of Couerbe was amorphous, but gave crystalline salts. That of Merck was crystallizable, but the salts noncrystalline save the gold double salt. The third is perhaps an isomeric form of the second.

These bases were given the following names for the logical reason which follows:

(*a*) Veratrine, because the prior right to the name rests with this base and because it forms veratric acid by saponification.

(*b*) Cevadine, because it forms cevadic acid and because it is not identical with the true veratrine.

(*c*) Cevadalline, because it appears to form cevadic acid and because in insolubility in ether it corresponds with the "sabadilleïne" of Weigelin and Dragendorff, which was not observed by them. The fact that other experimenters found that the greater part of the alkaloid was crystallizable, was satisfactorily explained by the fact that a trace of a noncrystalline substance interfered with the crystallizing powers of the base.

The method of extraction as given by Wright and Luff, differed widely from those which had hitherto been used. The omission of alkalies owing to the great danger of saponification was of the most importance as partial saponification and therefore considerable loss must have occurred in all of the previous methods, even in the use of ammonia. The method was briefly as follows: The coarsely powdered material was extracted with alcohol acidulated with tartaric acid (1 part of acid to 100 parts of the material) evaporated to a small bulk and the resin removed by the addition of water. The alkaloids were then extracted by repeatedly shaking with ether, the ether being treated with tartaric acid. The tartaric acid was then neutralized with sodium carbonate and shaken with a large quantity of ether. On evaporating the ethereal solution, a substance remained which refused to crystallize. By treating with benzoline a viscid, honey-like mass remained. A part, however, dissolved and appeared as imperfect crystals on evaporation. The crystals were removed and purified by redissolving in hot alcohol. The pure crystals melted at 205° C. and were undoubtedly identical with Merck's, and Schmidt and Köppen's veratrine. On account of its properties it was called cevadine. It forms cevadic acid by saponification.

In order to isolate the second base present as much as possible of the cevadine was removed and the insoluble portion

purified by treating with tartaric acid and sodium carbonate, extracting with ether and finally treating with benzoline. A substance was thus obtained which corresponded with Couerbe's veratrine. Analyses gave numbers for the formula,

$$C_{37} H_{53} N O_{11}.$$

On a saponification with alcoholic sodium hydroxide the base breaks up into veratric acid (dimethylprotocatechuic acid) $C_9 H_{10} O_4$, and a base resembling closely cevine, $C_{28} H_{45} N O_8$.

$$C_{37} H_{53} N O_{11} + H_2 O = C_9 H_{10} O_4 + C_{28} H_{45} N O_8 .$$

In their examination of crystallized veratrine Wright & Luff showed that it was a distinct alkaloid, that it probably did not exist in an isomeric form; that it yielded cevadic acid and a new base which they named cevine, by treating with alcoholic potassium hydroxide or heating in a closed tube at 200° C. By a series of analyses they arrived at the formula

$$C_{32} H_{49} N O_9$$

and represented the saponification by the following reaction:

$$C_{32} H_{49} N O_9 + H_2 O = C_5 H_8 O_2 + C_{27} H_{43} N O_8 .$$

Although the base cevine was not studied, yet the derivatives. of cevadine itself were made and analyzed, which leaves no chance for doubt as to the correct conclusion.

It therefore appears that the veratrine of Merck and Schmidt and Köppen was not veratrine at all but cevadine which upon saponification yields cevine and cevadic acid. A comparison of analyses will serve to show their identity.

Calculated for $C_{32} H_{49} N O_9$	Merck.	Schmidt & Köppen.	Wright & Luff.
C=64.97	64.81	64.63	64.72
H= 8.29	8.71	8.62	8.57
N= 2.37	5.50	2.66	2.31
Gold in goldsalt 21.08	21.01	21.09	21.04

The above numbers are the mean of several analyses with the exception of the nitrogen determination by Merck which is undoubtedly the result of an error.

The structure of cevadine is still a mystery. It is known, however, that there is one hydroxyl group present, and from the succeeding experiments one methoxyl group.

Later Wright[16] made a careful estimation of all the alkaloids present in both *Veratrum album* and *Veratrum viride.* The results showed that the total amount of alkaloidal matter in *V. viride* was only about one-fifth of that present in *V. album.*

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(16) Journ. Chem. Soc. 35: 421.

The following gives the number of grams per kilogram of roots:

Alkaloid.	*Veratrum album*	*Veratrum viride.*
Jervine,	1.3 gr.	0.2
Pseudojervine,	0.4	0.15
Rubijervine,	0.25	0.2
Veratralbine,	2.2	trace
Veratrine,	0.05	trace
Cevadine	——	.43

Bossetti[17], in a discussion of veratrine, found that it existed in two isomeric forms—a crystalline and a non-crystalline. The crystalline he showed to be identical with cevadine, while the soluble form was regarded as veratridine. By treating these two forms with alcoholic barium hydroxide, the crystallized form broke down into angelic acid and cevidine,

$$C_{32}H_{49}NO_9 + 2H_2O = C_5H_5O_2 + C_{27}H_{45}NO_9$$

while the amorphous broke down into veratric acid and veratroïne,

$$2\,C_{32}H_{49}NO_9 + 2H_2O = C_9H_{10}O_4 + C_{55}H_{92}N_2O_{16}.$$

Ahrens[18], in an examination of cevadine or crystallized veratrine, obtained both cevadic or tiglic acid and angelic acid by treating the alkaloid with alkalies. With alcoholic potassium hydroxide tiglic acid was formed, but with alcoholic barium hydroxide angelic acid was liberated. Tiglic acid was also obtained by treating with concentrated hydrochloric acid. Both cevine and cevidine were examined as well as the isomeric forms[19] of the base itself.

Two bromine compounds were prepared. The tetra-compound was made by treating with excess of bromine water. Analysis gave numbers for the formula

$$C_{32}H_{49}NO_9Br_4\,,$$

while the second, the dibromide, was obtained by treating the tetrabromide with very dilute potassium hydroxide. Analysis gave the formula

$$C_{32}H_{49}NO_9Br_2\,.$$

Various oxidizing reagents were tried upon the base without satisfactory results. Acetaldehyde and carbon monoxide were obtained with chromic acid and acetic acid with potassium permanganate.

(17) Arch. Pharm. **1883**: 83.

(18) Ber. **23**: 2700.

(19) Ann. **185**: 224.

Of special interest is the result of a dry distillation of the alkaloid. At 197-200° C. a colorless acid was obtained which was identified as tiglic acid. At the same time a base was obtained which was identified as B picoline by comparing with the same base obtained from strychnine.

The formation of a pyridine derivative by destructive distillation undoubtedly indicates the presence of that base in the natural alkaloid, and helps materially toward the determination of the structural formula.

Salzberger,[20] in an exhaustive examination of *Veratrum album*, made use of two methods of extraction, one he called the "barium method," and the other the "metaphosphoric method." The phosphoric acid method proved best, the use of barium hydroxide undoubtedly producing a partial saponification of the alkaloid. From the crude material he isolated the following bases:

Protoveratrine,	$C_{32} H_{51} NO_{11}$
Protoveratridine,	$C_{26} H_{45} NO_8$
Pseudojervine,	$C_{29} H_{43} NO_7$
Jervine,	$C_{26} H_{37} NO_3$
Rubijervine,	$C_{26} H_{43} NO_2 + H_2 O$.

There is a remarkable resemblance between protoveratrine and cevadine and protoveratridine and cevidine. A brief comparison will show that these might easily be taken for one another:

Cevadine,	$C_{32} H_{49} NO_9$
Protoveratrine,	$C_{32} H_{51} NO_{11}$
Cevidine,	$C_{26} H_{45} NO_8$
Protoveratridine,	$C_{27} H_{45} NO_9$.

From the above formulas, and from a remarkable resemblance in general properties, it seems necessary that these bases should be again studied and compared.

A careful comparison of cevadine with the veratrine of Merck and Schmidt and Köppen has shown that they are the same substance. While historically, and for reasons already given, cevadine should take precedence, nevertheless, from the fact that the cevadine is the common veratrine alkaloid used at present in pharmacy, it seems best to retain the name which associates the alkaloid with the genus of plants from which it is obtained. The name veratrine has therefore been retained in the following experiments.

(20) Inaug. Dis. Erlangen 1890: Arch. Pharm. 238: 230.

EXPERIMENTAL PART.

The veratine on which the following experiments have been made is of a light gray color and appears, when highly magnified, as imperfect granular crystals. It is slightly soluble in water, very soluble in methyl, ethyl and amyl alcohols, in ether, acetone, chloroform and carbon disulphide. It appears, upon the evaporation of any of these solutions, as a light-brown varnish. On stirring this varnish-like mass with water, it changes to a granular semi-crystalline mass. It refused to crystallize from alcohol. The powdered form has a peculiar bitter, rasping taste, producing a certain numbness of the tongue if taken in very small quantities. This peculiarity readily distinguishes it from any of the other alkaloids. It is a violent sternutatory, producing intense irritation of the nasal mucous membrane. It retards the action of the heart even when taken in small quantities. It gives a slightly alkaline reaction, which is intensified when the alkaloid is dissolved in alcohol. It gives with dilute nitric acid a pale yellow solution; with concentrated nitric acid a brown color and a strong odor of acetic acid. With concentrated sulphuric acid it produces an orange red color, which, on standing for some time, becomes fluorescent; with a great excess of acid, it becomes intensely red in transmitted light. With concentrated hydrochloric acid, it produces a blood red color immediately which seems to be permanent. It changes, however, to a dark brown color on heating. If the red solution from the hydrochloric acid is rendered slightly alkaline with ammonia, the color changes to a dirty green even when the alkaloid is present in very small quantities. The melting point after repurifying was 146-148° C.

In order to determine, whether or not the substance in hand was identical with that described by Merck and Ahrens analyses of the free base were made together with the gold double-salt.

No reference was made by the above named investigators to the water of crystallization. Three determinations were made, the mean of which corresponded for one molecule of water.

I.	.2401 grm. of alkaloid dried at 100°—102 lost	....	0.0081 H_2O
II.	.3108 " " " " " " " "	....	0.0103 "
III.	.5124 " " " " " " " "	....	0.0164 "

Calculated for	Found		
$C_{32}H_{49}NO_9H_2O$.	I.	II.	III.
H_2O = 3.00.	3.33	3.31	3.2

Combustions of the dried substance gave the following:

I. 0.1933 grms. dried sub. gave.....0.4572 CO_2 and 0.1441 H_2O.
II. 0.2060 " " " " .....0.4874 " and 0.1513 "

Calculated for	Found	
$C_{32}H_{49}NO_9$.	I.	II.
C= 64.96	64.8	64.53
H= 8.29	8.4	8.16

The purity of the substances was further proved by the properties and the melting point of the gold double-salt which melts according to Merck and Ahrens at 178°—180°. The recrystallized double salt was found to have a melting point (uncorr.) of 178°—182°. The melting point of the base itself is not given by the above mentioned investigators. A gold determination gave the following results:

.2462 gr. dried salt gave	0.05171 Au.
Calculated for	Found
$C_{32}H_{49}NO_9 HCl \cdot AuCl_3$.	
Au= 21.08	21.00

METHOXYL DETERMINATION.

Wright and Luff[21] in their work on the alkaloids of the sabadilla stated that cevadine (which is undoubtedly identical with the Merck veratrine) contained one hydroxyl group. They verified the assumption by the introduction of a benzoyl group, forming a monobenzoyl veratrine

$$C_{32}H_{48}(C_7H_5O)NO_9.$$

The presence of tigic acid, B methylpropionic acid, was also indicated by its formation when the base was heated with water at 200°. They therefore ascribed to the base the following crude formula

$$C_{27}H_{48}NO_6\begin{matrix}OH\\ OOC—C(CH_3)—CH—CH_3\end{matrix}.$$

It would appear from this formula that the alkaloid contains no methoxyl group, although no record of such a determination has been given. In order to determine definitely the presence or absence of the methoxyl group, several analyses were made by the Zeizel method with the following results:

I. .2461 grams of dried sub. gave 0.0698 AgI.
II. .2021 grams of dried sub. gave 0.0636 AgI.

Calculated for	Found	
$C_{31}H_{46}NO_8(OCH_3)$,	I.	II.
OCH_3 =4.19	4.16	4.72

(21) Journal of the Chem. Society. **33**: 338.

THE IODIDES OF VERATRINE.

As stated by Ahrens[22] veratrine absorbs bromine readily, forming a tetrabromide

$$C_{32} H_{49} NO_9 Br_4$$

It was prepared by triturating veratrine with strong bromine water, when a yellow powder was formed which was purified by filtering and washing with warm water. It proved to be insoluble in water but readily soluble in alcohol, ether, chloroform and acetone.

On treating the tetrabromide with dilute potassium hydroxide, two bromine atoms were readily removed forming a light yellow dibromide

$$C_{32} H_{49} NO_9 Br_2.$$

Reference is also made to an iodide of veratrine[23] which was prepared by the action of iodine on a salt of veratrine. The formula given was

$$C_{32} H_{54} N_2 O_8 HI_3,$$

Veratrine tetraiodide, $C_{32} H_{49} NO_9 I_4 + 3H_2 O$.

A careful examination showed that iodine also combined readily with veratrine forming a series of compounds which in many respects resembled the bromides. By triturating veratrine with a strong alcoholic solution of iodine, a reddish brown substance was formed which upon examination appeared to be a mixture of several substances. This was also indicated by the varying melting point. A great excess of iodine was then added and the substance allowed to stand for several days when a beautiful light red crystalline substance was formed with a melting point of 129°-130°. It is very soluble in methyl and ethyl alcohol forming upon evaporation a dark brown waxy mass. It is soluble in acetone, forming a wax which upon standing becomes a dark red powder. It is insoluble in ether, benzole and water. By treating with sulphurous acid, the red color disappeared and a light yellow powder is formed which was afterward identified as the monoiodide. With dilute ammonia the same substance is formed but, with concentrated ammonia, a white, gelatinous substance is formed with some of the properties of the free base. An examination showed it to be different from the free alkaloid, although all of the iodine had been removed.

Great difficulty was experienced in the determination of water of crystallization. It was found after several determinations,

(23) Ber. 23: 2700.
(22) Arch. Pharm [III], 5: 283.

that four hours drying at 100°-102° was necessary to remove the three molecules of water present. It was also found that by drying at 104°-106° some of the iodine was driven off. This explained the difficulty in obtaining satisfactory results in the early analysis. A careful determination of moisture was made raising the temperature gradually to 114°, with the following results:

2.362	grm.	substance	dried	at	100°	for 2	hours,	lost....	0.082
“	“	“	“	“	100–102°	for 2	hours	lost	0.118
“	“	“	“	“	100–102	“	“	“	0.119
“	“	“	“	“	100–104	“	“	“	0.152
“	“	“	“	“	100–104	“	“	“	0.179
“	“	“	“	“	100–105	“	“	“	0.190
“	“	“	“	“	100–105	“	“	“	0.224
“	“	“	“	“	100–105	“	“	“	0.224
“	“	“	“	“	102–106	“	“	“	0.240
“	“	“	“	“	102–106	“	“	“	0.247
“	“	“	“	“	104–107	“	“	“	0.276
“	“	“	“	“	104–107	“	“	“	0.299
“	“	“	“	“	105–108	“	“	“	0.327
“	“	“	“	“	105–109	“	“	“	0.341
“	“	“	“	“	105–110	“	“	“	0.382
“	“	“	“	“	105–110	constant	“	“	0.382
“	“	“	“	“	110–112	“	“	“	0.389
“	“	“	“	“	112–112	“	“	“	0.402
“	“	“	“	“	112-114	“	“	“	0.414

The substance showed decided indications of decomposition at 112–114°, and at 120° began to frit, changing to an almost black waxy mass As will be seen from the above numbers. the substance dried to constant weight at 100° loses three molecules of water.

2.362 dried at 100° lost 0.118 water

Calculated for

$C_{32}H_{49}NO_9I_4 + 3H_2O$	Found
$3H_2O = 4.68$	4.99

It was found, on examination, that the loss which occurred by heating above 102° was due to iodine, and that by drying at 110° to constant weight one-fourth of the iodine could be driven off.

2.362 grm. substance dried to constant weight at 110° lost 0.382 $I + H_2O$.

Calculated for

$C_{32}H_{49}NO_9I_3 + I + 3H_2O$	Found
$I + 3H_2O = 15.7$	16.17

An attempt to remove another atom of iodine was unsuccessful, as is indicated by the above experiment, although the loss

which occurred between 110–114° was due to the liberation of iodine.

An analysis of the substance dried at 100° to constant weight was made with the following results:

.2231 grms. of dried iodide gave .2834 grms. CO_2 and .0912 H_2O

Calculated for $C_{32}H_{49}NO_9I_4$	Found
C=34.94	34.64
H= 4.45	4.9

Veratrine triiodide $C_{32}H_{49}NO_9I_3$. The red iodide dried at 110° to constant weight became a dark brown amorphous powder which showed no signs of crystallization on treating with water, It is insoluble in ether and much less soluble in methyl and ethyl alcohol than the tetraiodide. It melts at 136°–138°.

Analyses gave the following results:

I. .2034 grams of sub. gave .2938 grms. CO_2 and .1152 H_2O.
II. .1945 grams of sub. gave .1405 grms. Ag I.

Calculated for $C_{32}H_{49}NO_9I_3$	Found I.	Found II.
C=39.5	39.37	
H=6.36	6.28	
I=39.2		38.6

While it was evident that more than one-fourth of the iodine could be driven off by drying, repeated attempts to obtain the diiodide were unsuccessful.

Veratrine monoiodide $C_{32}H_{49}NO_9I$. By treating the tetraiodide with dilute ammonia and allowing to stand for several hours in a warm place, the bright red color disappeared and a light yellow granular substance was formed. It proved to be insoluble in water, ether and chloroform, but very soluble in methyl and ethyl alcohols. A bright yellow powder is formed on evaporating off the alcohol. It does not form the waxy mass which characterizes the tetraiodide. It was obtained from a dilute alcoholic solution as a fine crystalline powder with a melting point of 212°–214°. It contains two molecules of water which were removed by drying at 100°.

.3782 grm. of substance dried at 100° lost 0.018. H_2O.

Calculated for $C_{32}H_{49}NO_9I+2H_2O$.	Found
$2H_2O$=4.77	4.76

An analysis gave the following:

0.1763 grms of the dried sub. gave 0.0583 Ag I.

Calculated for $C_{32} H_{49} NO_9$ I.	Found
I=17.68	17.87

On digesting with strong ammonia for a short time the iodide was completely removed, and a white insoluble gelatinous substance was formed which at first was regarded as the free alkaloid. An examination showed that it differed from veratrine in general appearance and solubility. It melted at 189°.

OTHER COMPOUNDS.

Chloralhydroveratrine $C\,Cl_3\,CH \begin{matrix} O\,(C_{32}\,H_{48}\,NO_8\,) \\ O\,(C_{32}\,H_{48}\,NO_8) \end{matrix}$ As stated by Wright and Luff[24] veratrine heated at 100° with twice its weight of benzoic anhydride, is converted into a monobenzoylveratrine

$$C_{32}\,H_{48}\,(C_7\,H_5\,O)\,NO_9\,.$$

The formation of this compound proved the presence of one hydroxyl group. The writer repeated the experiment in order to determine whether or not more than one hydroxyl group existed in the alkaloid. The impossibility of making more than the mono derivative was sufficient evidence that but one group existed. It was found, however, that this group was so loosely held that it could be replaced by treating with almost any anhydride. Chloral was found to react vigorously on the alkaloid, producing a sort of effervescence. With excess of chloral the alkaloid dissolves. With a smaller quantity a waxy mass is formed which readily changes to a creamy white granular powder. This powder was washed thoroughly with ether to remove the free chloral. The substance in the pure state was almost white and crystalline. A determination showed the reaction to be quantitative. Five grams of the veratrine gave 6.1 grams of the pure chloral compound. It is insoluble in ether and chloroform, but very soluble in water and alcohol. It melts at 220°. In its physiological properties it resembles veratrine. It is a most powerful sternutatory, producing the most violent irritation of the nasal mucous membrane. In the most minute quantities it effects the eyes, causing intense pain and contracting the pupil. It is a remarkable local irritant. Applied to the moistened skin and rubbed it produces blisters. It is readily decomposed by alkalies. Ammonia decomposes it forming chloral hydrate and veratrine. It is hygroscopic, taking on two

(24) Journ. Chem. Soc. 32: 351.

molecules of water if exposed to the air for some time. The water can readily be removed by drying at 100°.

Analysis gave the following numbers:

I. .2394 grms. of dried substance gave .5280 CO_2 and .1530 H_2O.
II. .1692 " " " " .0502 Ag Cl.

Calculated for $C Cl_3 CH (OC_{32} H_{49} NO_8)_2$	Found I	Found II
C= 60.38	60.2	
H= 7.38	7.1	
Cl= 8.2		7.35

The alkaloid formed by the action of ammonia upon the substance was carefully examined in the hope of finding the isomeric base of Schmidt and Köppen. Although the base seemed to have a few different properties from the original veratrine, the gold double salt had exactly the same properties and melting point of the original gold salt.

Veratrine methyliodide, $C_{32} H_{49} NO_9 \cdot CH_3I$. From the resemblance of veratrine to the alkaloids narcotine and narceine, it was believed that it would form a compound with methyl iodide. It was found, on treating the base with excess of methyl iodide, that the substance readily dissolved with the exception of a very small quantity of gelatinous substance, which was found to be an impurity. In allowing the filtered solution to stand for some hours, or by heating on a water bath with a reflux condenser, the whole of the base precipitated out as a solid, yellow, crystalline mass. The reaction was complete at the end of an hour on the water bath, but it required several days at the ordinary temperature to completely convert it into the iodide. Excess of the methyl iodide was then evaporated off and the veratrine compound treated with ether to remove any trace of the unchanged alkaloid. The iodide thus obtained was a light yellow crystalline powder, insoluble in ether and chloroform, and soluble in methyl and ethyl alcohols. It is soluble in hot water, from which it can be obtained as an almost white crystalline powder. It melts at 210°–212° with apparent decomposition.

It contains 1.5 molecules of water of crystallization which can be removed by drying at 100°.

I. 0.3547 grms. dried to constant weight at 100° lost .0132
II. 1.1180 " " " " " " " " .0431

Calculated for $C_{32} H_{49} NO_9 \cdot CH_3 I + 1.5 H_2O$.	Found I.	Found II.
$1\frac{1}{2} H_2O$= 3.55	3.72	3.85

Analysis gave the following numbers:

1. .2131 grms. of dried substance gave .4243 CO_2 and .1440 H_2O.

II. .2034 " " " " " .0638 Ag I.

Calculated for $C_{32}H_{49}NO_9CH_3I$.	Found I.	Found II.
C= 54.03	54.28	
H= 7.1	7.35	
I=17.32		16.94

Veratrine methylhydroxide, $C_{32}H_{49}NO_9 \cdot CH_3OH$. It was found that the iodine in the veratrine methyliodide could be removed by treating with sodium or potassium hydroxide. The iodide was dissolved in water and dilute sodium hydroxide cautiously added. The solution soon began to turn brown and after several hours a complete decomposition had taken place. Examination showed that two distinct substances had been formed, one, a waxy substance which refused to crystallize and a crystalline substance which was sparingly soluble in water. The reaction seemed deep seated but is probably closely associated with that given by Wright in the preparation of cevine by saponification.

A solution of the methyliodide was again treated with freshly precipitated silver oxide and warmed. It was found that above 45° the solution again turned brown, indicating decomposition. The experiment was repeated without warming the solution. Five grams of the methyliodide were placed in a shaking flask with 200 cc of water, an excess of silver oxide added and shaken for 12 hours at the ordinary temperature. At the end of that time a reaction seemed to be complete. The silver iodide and excess of silver oxide were removed by filtration. An attempt to concentrate a part of the clear solution by evaporating on a water bath proved unsuccessful, for between 40° and 65° decomposition began and in a half hour the whole solution became almost black.

A second portion of the clear solution was evaporated at the ordinary temperature. At the end of three days, a residue was obtained as a white granular powder. The substance proved to be exceedingly unstable, turning gray and finally brown on gently warming. It is soluble in water, methyl and ethyl alcohols and in acetone; slightly soluble in ether and chloroform. It differs materially from veratrine. It is a non-sternutatory and appears to be physiologically inactive. It changes to a brown mass between 80° and 90° but does not finally melt until the temperature is raised to 188-190°. It contains water of

crystallization which was removed by heating in an air bath at 60° for two hours. More satisfactory results however were obtained by drying over sulphuric acid *in vacuo.*

.3958 grms. dried to constant weight lost 0.0320.

Calculated for	Found
$C_{32}H_{49}NO_9 \cdot CH_3OH + 2H_2O.$	
$3H_2O = 8.2$	8.09

.2022 grms. of the dried substance gave .4828 CO_2 and .1557 H_2O.

Calculated for	Found
$C_{32}H_{48}NO_9 \cdot CH_3.$	
C=65.45	65.13
H=8.43	8.01

The apparent change which took place in the substance on drying is evidently deep seated. The white granular substance on drying, became a fine light gray amorphous powder which is only slightly soluble in water. These changes, together with the comparative ease with which the substance decomposes would indicate that a part of the water exists as water of constitution. This supposition is admirably borne out by the analyses.

Veratrine methylhydroxyhydrochloride, $C_{32}H_{49}NO_9 \cdot CH_3OH\ HCl$. Veratrine methylhydroxide is very soluble in acids and readily decomposed by strong acids. Sulphuric acid decomposes it changing first to a bright red color, and finally, with decomposition to a black, tar-like mass. Hydrochloric acid gives a red color if the acid is strong. Very dilute acid dissolves it, leaving a perfectly clear solution. If this clear solution is allowed to evaporate spontaneously, a light gray granular powder is formed. It is soluble in water, and can be obtained by spontaneous evaporation. It is soluble in methyl and ethyl alcohols. It forms a light, amber-colored varnish on evaporating off the alcohol. It is very unstable, decomposing below 100°. It seemed to change upon standing over sulphuric acid for some time.

.2065 grams of substance dried over sulphuric acid gave .4444 CO_2 and .1311 H_2O

Calculated for

$C_{32}H_{49}NO_9 \cdot CH_3OH\ HCl$	Found
C=60.00	58.67
H=8.24	6.6

It is evident that the water of constitution is held more firmly here than in the free base.

Gold double salt $(C_{32}H_{49}NO_9 \cdot CH_3OH \cdot HCl)AuCl_3$. An attempt to make the gold double salt from the hydrochloride did not prove successful. A decomposition took place on adding the gold chloride, apparently caused by excess of acid. A better method was found by treating the methyl hydroxide with gold chloride which had been rendered slightly acid with hydrochloric acid. A beautiful lemon yellow crystalline powder was formed. It was filtered off, washed with hot water and dried on an unglazed porcelain plate. The substance thus purified melted at 149°. It is soluble in alcohol but sparingly soluble in water, ether and chloroform. It is comparatively stable, remaining unchanged at 110°. A determination of water of crystallization was not made. A gold determination gave the following:

.1716 grams of the dried salt gave 0.0362. Au.

Calculated for $(C_{32}H_{49}NO_9 \cdot CH_3OH \cdot HCl)AuCl_3$	Found
Au=21.41	21.09

Veratrine ethylbromide $C_{32}H_{49}NO_9 \cdot C_2H_5Br$. Veratrine dissolves readily in ethyl bromide, and combines slowly to form the veratine bromide. It was found that heating on a water bath with reflux condenser for six hours was necessary to convert it all into the ethyl compound. At the end of the reaction the excess of ethyl bromide was evaporated off, leaving the veratrine ethyliodide as a light yellow amorphous mass. By treating with water and stirring for some time, the substance was obtained in crystalline form. It is sparingly soluble in water, but readily soluble in methyl and ethyl alcohols. It decomposes readily. It shows signs of decomposition at 60°, and at 100° it seems completely changed. It does not finally melt, however, until a temperature of 160° is reached. The substance purified by boiling water was dried and analyzed. The result showed that a decomposition had taken place and that a tetrabromide of veratrine was formed. The ethylene odor was noticed in the boiling. Analysis of the substance thus treated with water gave the following numbers:

I .2270 grms. of dried substance gave .4591 CO_2 and .1603 H_2O
II .2228 " " " .0200 Ag Br.

Calculated for $C_{32}H_{49}NO_9Br_4$	Found I.	Found II.
C= 42.15	42.55	
H= 5.38	7.84	
Br= 35.06		38.73

Veratrine allyliodide $C_{32} H_{49} NO_9 \cdot C_3 H_5 I$. By digesting veratrine with allyliodide on a water bath for several hours, a solid but slightly waxy looking substance was formed. The excess of allyliodide was removed and the veratrine compound washed thoroughly with ether. The substance thus purified appeared partially crystalline but changed on standing in the air to a semi-waxy mass. Exposed for some time to the air or by treating with a small quantity of water and stirring, the substance again becomes granular. The substance was finally purified by dissolving in a small quantity of alcohol and precipitating with ether. The pure iodide is an almost white crystalline powder. It is soluble in ethyl and methyl alcohols and acetone. It melts at 235°-236°. It contains one molecule of water which can be removed by drying at 100°.

I. .1990 grms of the dried sub. gave 0.4000 CO_2 and .1202 H_2O
II. .3022 " " " " " 0.0954 Ag I.

Calculated for	Found	
$C_{32} H_{49} NO_9 \cdot C_3 H_5 I$	I	II
C=55.29	54.81	
H= 7.1	6.71	
I=16.73		17.01

An attempt to obtain the free base by shaking with silver oxide was unsuccessful. The solution turned brown at the ordinary temperature giving off the order of allylalcohol.

The structural formula for veratrine is still a mystery. From the odor of picoline by a destructive distillation and isolation of B picoline by Ahrens[25] it is evident that veratrine is a pyridine derivative, resembling in many respects nicotine. Whether both cevadic and tiglic acids are present remains for future experiments to determine. The work of Schmidt and Köppen indicates the presence of both acids while the careful researches of Wright and Luff would indicate that these isomeric acids were converted into each other by special reagents. Assuming that but one acid is present the following formula may be assigned to veratrine:

$$C_{21} H_{35} O_5 \begin{cases} O\ CH_3 \\ O\ H \\ O\ O\ C\ C\ H\ (CH_3)\ CH_3 \\ N\ H_7\ C_6 \end{cases}$$

Experiments are being conducted at present along this line with the hope of throwing more light on the structure of this important compound.

(25) Ber. 23: 2700.

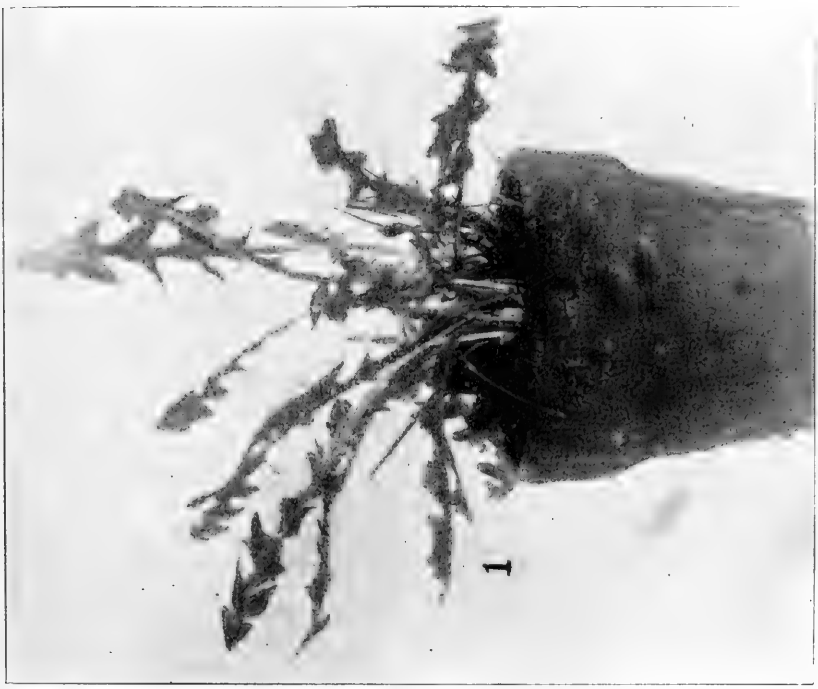


PLATE XL.

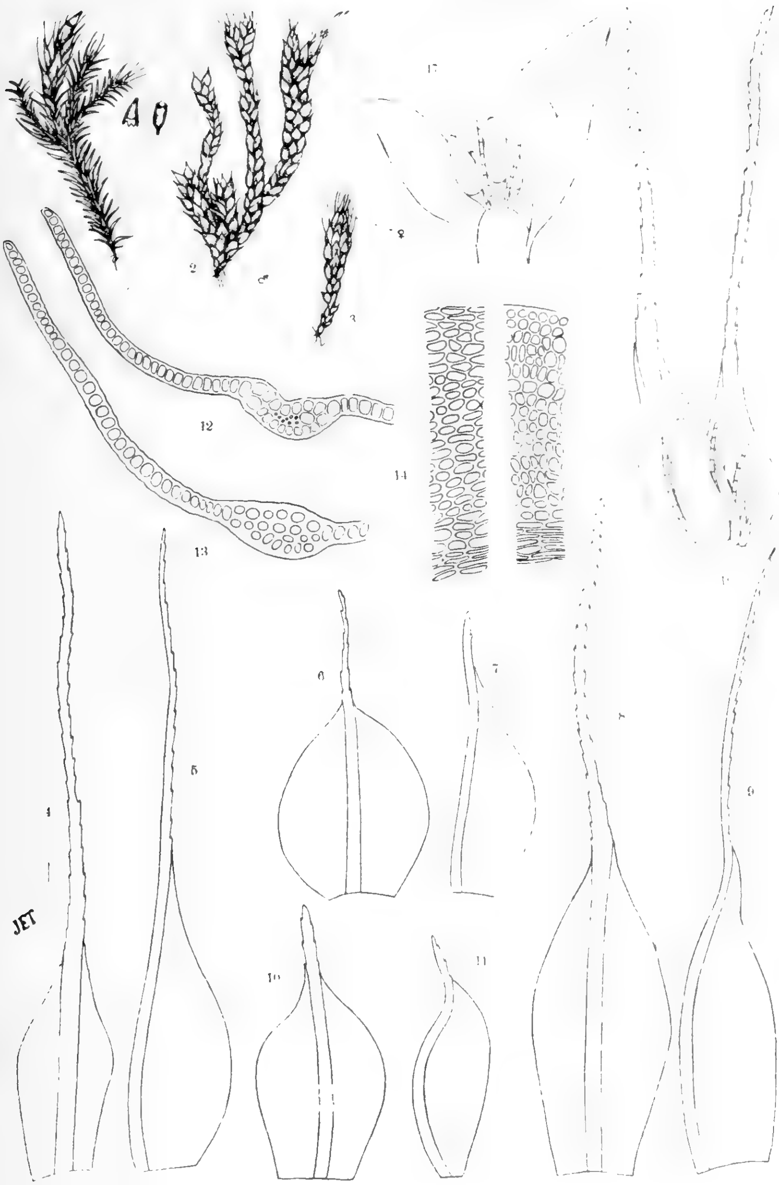


PLATE XLI.

E.G.H del

PLATE XLII.

ACROSTICHUM HELLERI UNDERW.

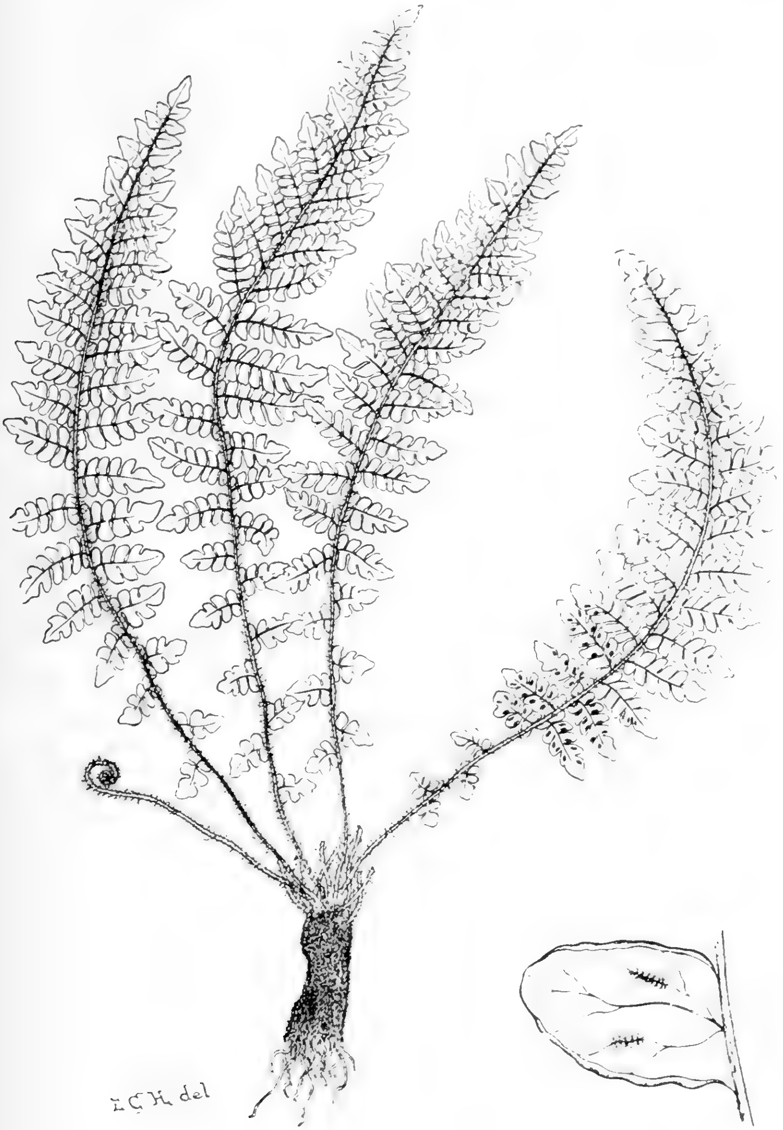


PLATE XLIII.

GYMNOGRAMMA SADLERIOIDES UNDERW.

PLATE XLIV.

SYNTHERISMA HELLERI NASH.

PLATE XLV.

ASTELIA MENZIESIANA SM.

PLATE XLVII.

PIPTURUS RUBER HELLER.

E.G.H. del.

PLATE XLVIII.

Pelea cruciata Heller.

E.G.H. del.

PLATE XLIX.

PELEA MICROCARPA HELLER.

PLATE L.

Euphorbia atrococca Heller.

PLATE LI.

EUPHORBIA RIVULARIS HELLER.

PLATE LII.

EUPHORBIA SPARSIFLORA HELLER.

PLATE LIII.

HIBISCUS WAIMEAE HELLER.

PLATE LIV.

ISODENDRION SUBSESSILIFOLIUM HELLER.

E. G. H. del

PLATE LV.

NANI(A) PUMILA HELLER.

PLATE LVI.

NANI(A) TREMULOIDES HELLER.

E.G.H del.

PLATE LVII.

LYSIMACHIOPSIS DAPHNOIDES (A. GRAY) HELLER.

E.C.H.DEL.

PLATE LVIII.

LYSIMACHIOPSIS HILLEBRANDII (HOOK.) HELLER.

E. G. H. del.

PLATE LIX.

CYRTANDRA GAYANA HELLER.

PLATE LX.

GOULDIA ELONGATA HELLER.

PLATE LXI.

GOULDIA SAMBUCINA HELLER.

E.G.H. del.

PLATE LXII.

STRAUSSIA PUBIFLORA HELLER.

E. G. H. del.

PLATE LXIII.

STRAUSSIA PSYCHOTRIOIDES HELLER.

E.G.H. del.

PLATE LXIV.

CYANEA CORIACEA (A. GRAY) HILLEBR.

PLATE LXV.

Cyanea spathulata (Hillebr.) Heller.

E.G.H. del.

PLATE LXVI.

CYANEA SYLVESTRIS HELLER.

PLATE LXVII.

LOBELIA TORTUOSA HELLER.

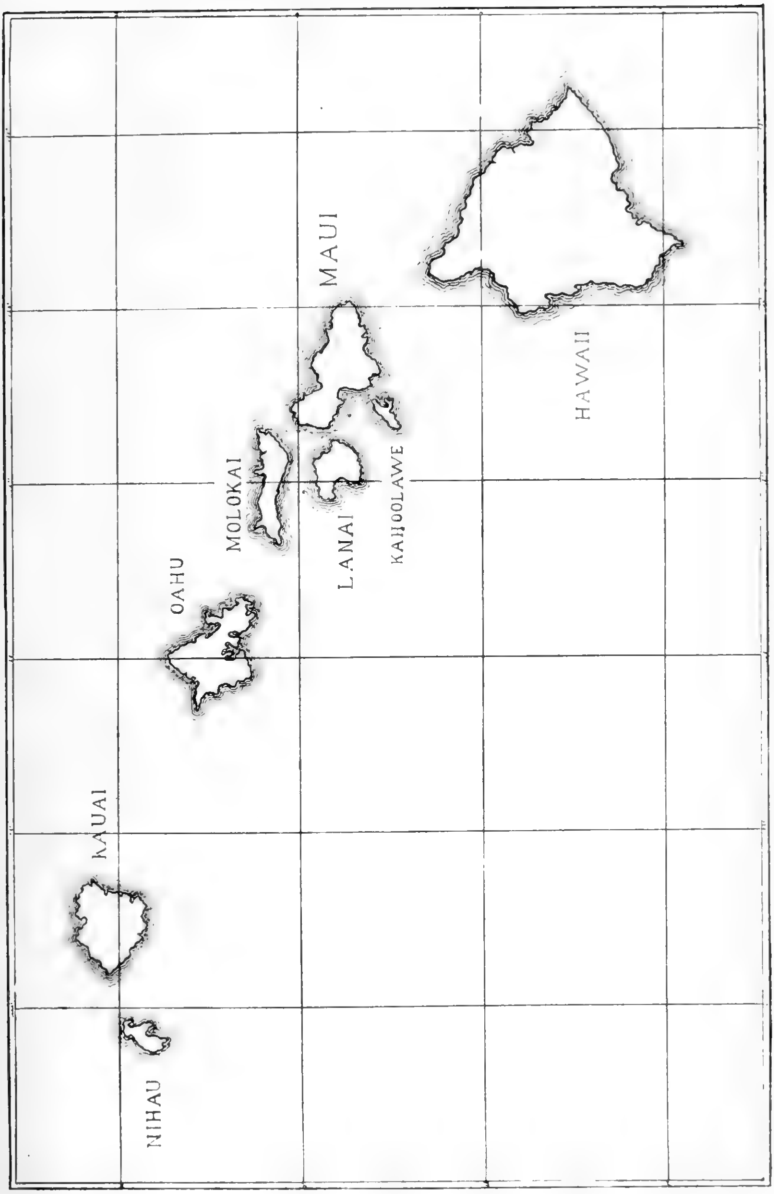


PLATE LXVIII.

Map of the Hawaiian Islands, showing the relative position of the different inhabited islands.

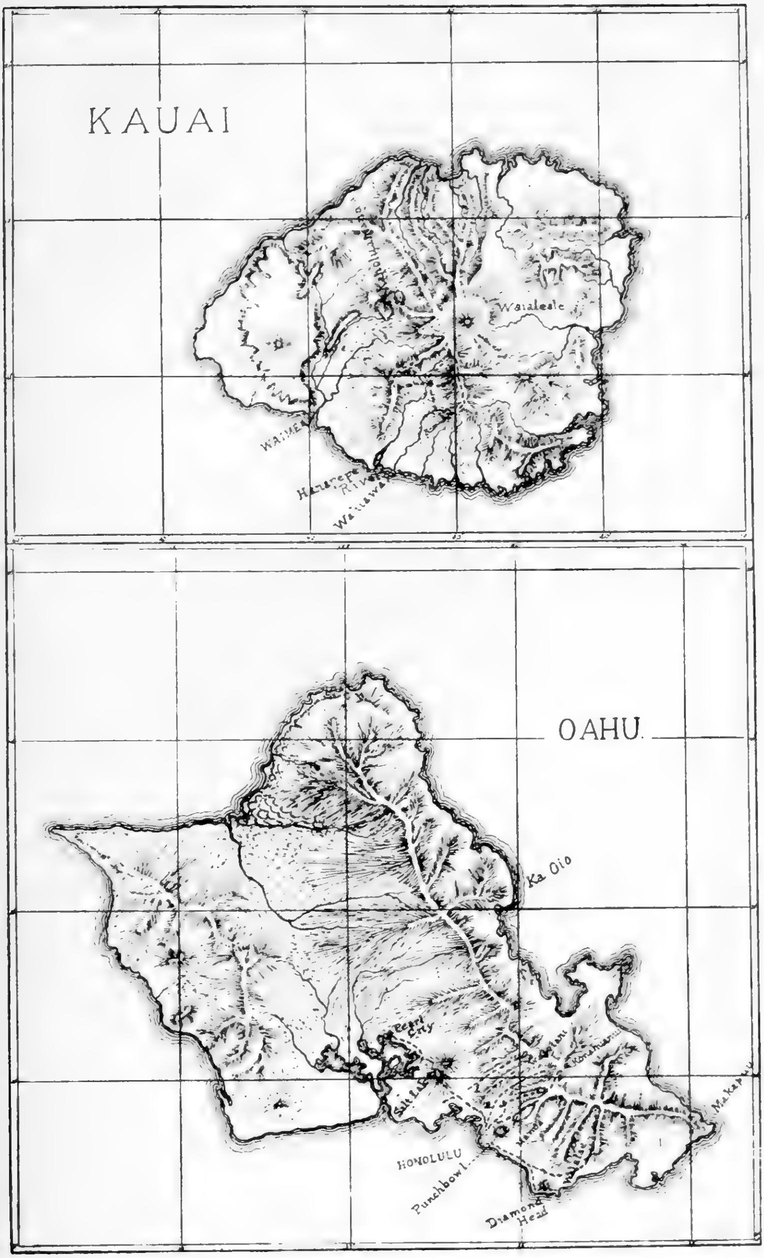


PLATE LXIX.

Map of the islands of Oahu and Kauai. The dotted lines show the places explored.

PLATE LXX.

PLATE LXXI.

PLATE LXXII.

PLATE LXXIII.

PLATE LXXIV.

PLATE LXXV.

PLATE LXXVI.

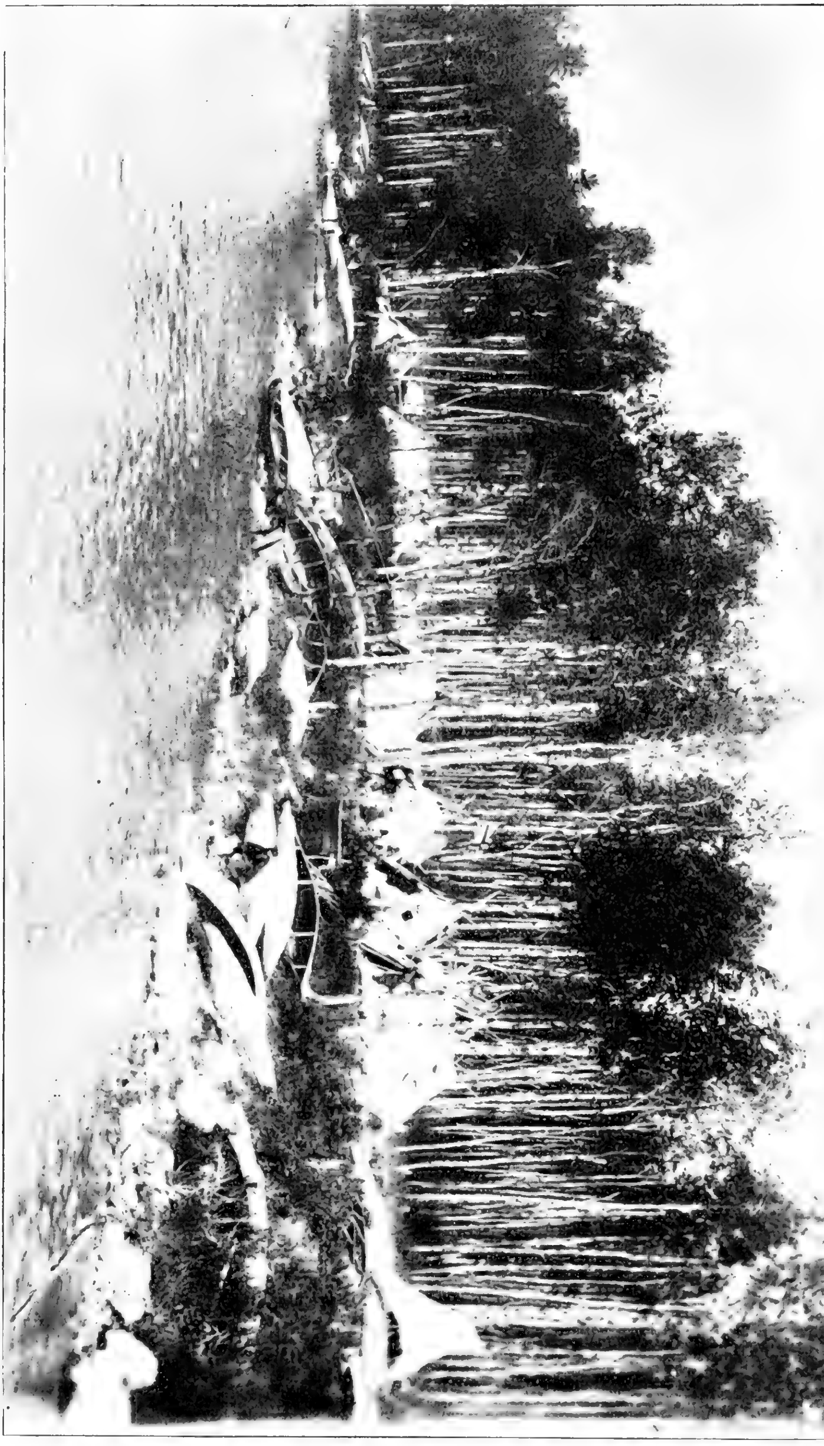


PLATE LXXVII.

PLATE LXXV.

PLATE LXXIX.

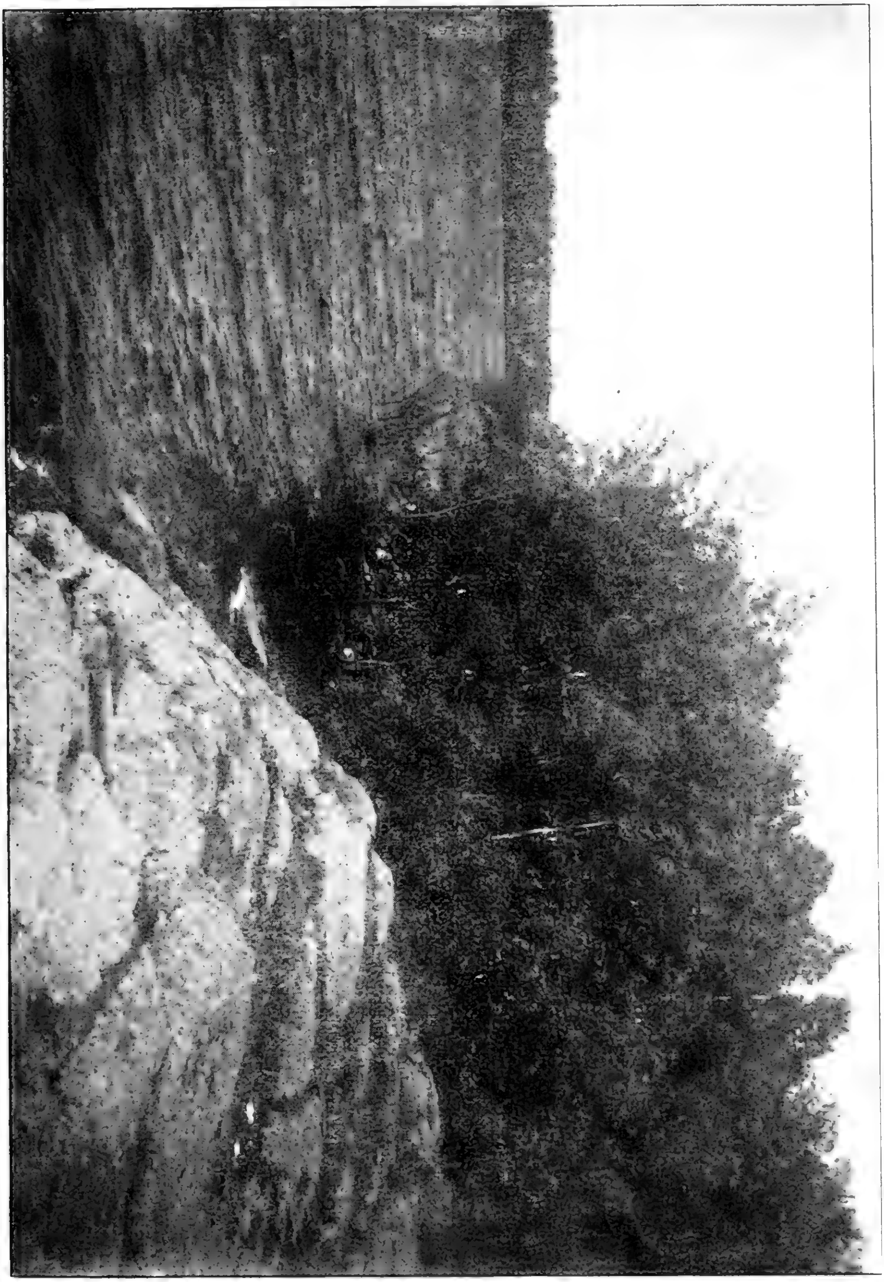
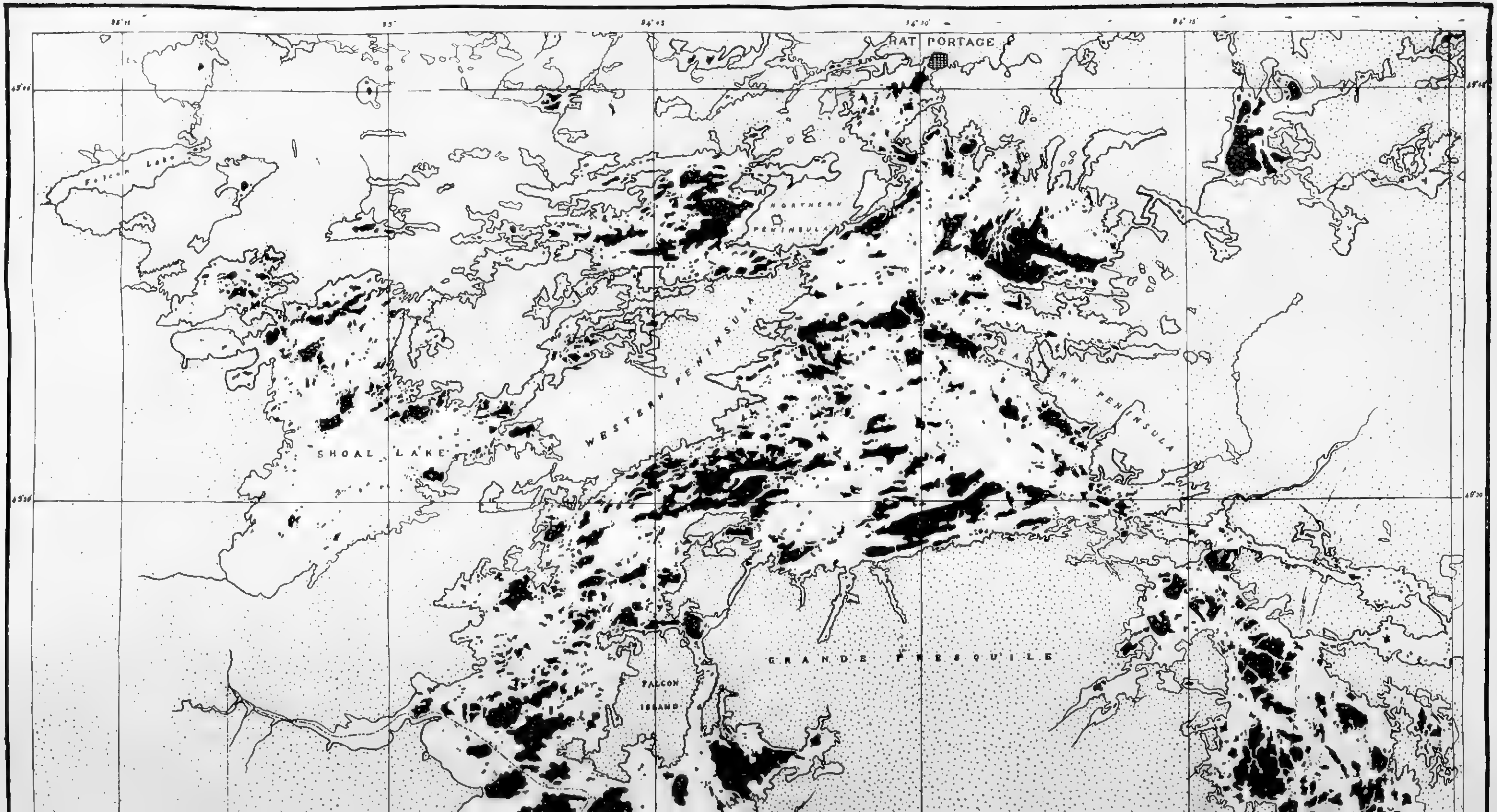
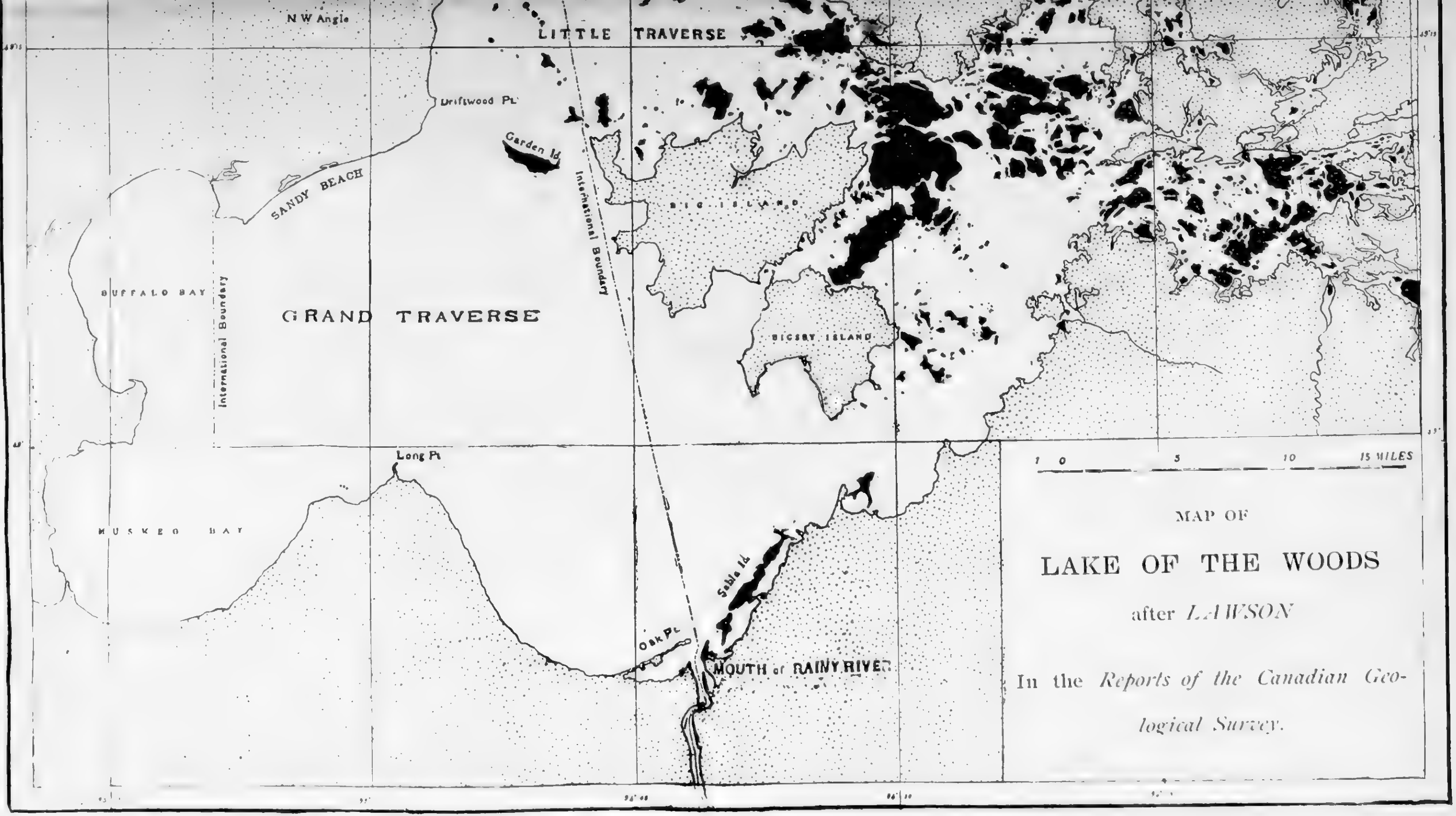


PLATE LXXX.


RAT PORTAGE
Falcon Lake
NORTHERN PENINSULA
WESTERN PENINSULA
EASTERN PENINSULA
SHOAL LAKE
GRANDE PRESQUILE
FALCON ISLAND



N W Angle
LITTLE TRAVERSE
Driftwood Pt.
Garden Id
International Boundary
SANDY BEACH
BIG ISLAND
BUFFALO BAY
GRAND TRAVERSE
BIGSBY ISLAND
Long Pt
MUSKEG BAY
Sable Id
Oak Pt
MOUTH of RAINY RIVER
1 0 5 10 15 MILES
MAP OF
LAKE OF THE WOODS
after *LAWSON*
In the *Reports of the Canadian Geological Survey.*

PLATE LXXXI.

INDEX

OF PLANT NAMES.

Accepted names are in Roman. Synonyms are in *italics*.

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